B. Ticknor

A SYSTEM OF CHEMISTRY FOR THE USE OF STUDENTS OF MEDICINE.

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EASTERN DISTRICT OF PENNSYLVANIA, to wit:

SEAL. BE IT REMEMBERED, that on the twenty-seventh day of November, in the forty-fourth year of the Independence of the United States of America, A. D. 1819, Franklin Bache, M. D. of the said district, hath deposited in this office, the title of a book, the right whereof he claims, as author, in the words following, to wit:

"A System of Chemistry for the Use of Students of Medicine. By Franklin Bache, M. D. Member of the Academy of Natural Sciences of Philadelphia."

In conformity to the act of the Congress of the United States, intituled, "An act for the encouragement of learning, by securing the copies of maps, charts, and books, to the authors and proprietors of such copies during the times therein mentioned."—And also to the act, entitled, "an act supplementary to an act, entitled 'an act for the encouragement of learning, by securing the copies of maps, charts, and books, to the authors and proprietors of such copies during the times therein mentioned,' and extending the benefits thereof to the arts of designing, engraving, and etching historical and other prints."

D. CALDWELL,
Clerk of the District of Pennsylvania.

PREFACE.

My object, in writing the following pages, has been to present, to the Student of Medicine, an elementary work on Chemistry, in which the more important bearings of the science on his profession might constantly be kept before his view.

To answer this particular intention of the work, I have given a fuller consideration to those parts of the science, which have some direct relation or application to Medicine. Thus, whenever I come to treat, in pursuing the scientific order of the work, of any particular chemical substance, which constitutes a part of the materia medica, I have uniformly given its pharmaceutical preparation, and taken some notice of its medicinal properties. When the subject of vegetables is taken up, I have contented myself with giving a rapid view of their proximate constituents; dwelling more particularly on those, which constitute the active principles of the more powerful vegetable medicines, such as emetin, morphia, strychnin, &c. and on those, which are the chief ingredients in nutritious vegetable matter, as sugar, starch, gluten, &c.

In passing from the consideration of vegetable to animal matter, the principal intention of the work is still kept in view. Animal chemistry generally, and in its particular application to the human body, is essential to be known by the student of medicine. This part of the subject is first treated of generally, and afterwards with particular reference to the chemical nature of the various parts of the human structure. The animal functions, which are elucidated by chemistry, such as respiration, assimilation, and secretion, are next cursorily noticed.

Such, then, is the plan, upon which the present work has been conducted, to fit it for the use of those, who study chemistry with a view to medicine. These explanations being premised, it is next proper to say something of the general arrangement of the work, without reference to its use by any particular class of readers.

As is most usual in chemical works, I have first treated of the science of chemistry, strictly so called, and afterwards applied the knowledge, thus afforded, in ascertaining the chemical properties of matter in its complex forms, as it occurs most generally in nature.

The science of chemistry commences with the consideration of matter, and is completed with a short account of the general principles, upon which chemical actions occur. In treating of matter, contrary to the common usage, I have commenced with

its ponderable forms, and afterwards taken up the consideration of imponderable matter. In pursuing this course, I have been influenced by the general principle, that, in works intended to convey elementary information, it is proper to proceed, as far as practicable, from the easy to the more difficult parts of the subject. I have considered the attractions, with which chemistry is concerned, after matter, since all that can be said upon this subject must be the result of the generalization of chemical facts. To have pursued a contrary order, would have been to disregard the fundamental principle of proceeding from the known to the unknown.

In treating of ponderable matter, those forms of it, which have as yet resisted the efforts of analysis, are first considered, under the title of undecompounded bodies. I have adopted the term, *undecompounded*, from Sir H. Davy, and have uniformly used it in place of the word *simple*, on account of its expressing, with precision, the idea intended to be conveyed.

In arranging the undecompounded ponderable bodies, I have adopted Dr. Thomson's primary divisions, of supporters of combustion, incombustibles, and combustibles. In treating of the combustibles, however, I have deviated somewhat from the arrangement of this chemist, by adding a class of acidifying combustibles, and in giving a peculiar meaning to the epithet *intermediate*, as applied to these bodies. The reasons, which have influenced me in adopting these modifications, have been fully given in the chapter, explaining the arrangement of the undecompounded bodies. It may be proper, however, to mention in this place, that I have ventured to propose the epithet *basifiable*, to designate the combustible radicals of salifiable bases. I have found this word so useful on many occasions in the progress of the work, that I have been induced to hope, it will not be deemed an injudicious suggestion.

Immediately after the undecompounded bodies, I have thought it most adviseable to notice the atomic theory. I could not speak of it sooner with any prospect of making myself intelligible, and to delay it for insertion in the latter part of the work, would have been to lose the advantage of its application. After this theory has been laid before the reader, all analyses, as far as practicable, are given atomically. Those, however, which had been previously given, are expressed in numbers, adjusted in accordance with the theory. The plan of Mr. Dalton, of assuming the weight of the atom of hydrogen as unity, has been adopted. The weights of the atoms of all the other chemical substances are greater than the weight of the atom of this body, and, at the same time, exact multiples of it. In having pursued this plan, therefore, the advantage has been gained of avoiding fractions in the equivalent numbers of the different chemical substances.

The compound ponderable bodies are considered under the four heads of salifiable bases, acids, salts, and unsalifiable compounds. The expression, salifiable base, as applicable to those bodies, which form, with acids, neutral compounds, for the most part crystallizable and soluble, is sanctioned by the usage of the best chemical writers of the present day, and may now be considered as constituting a part of the scientific language of chemistry. This mode of appellation, I have adopted without hesitation, but I have not followed the usual nomenclature of the divisions of the salifiable bases. Thus I have used the expression of *alkaline salifiable bases*, to designate the compounds, usually distinguished by the separate appellations of alkalies, and alkaline earths, retaining no division corresponding to the latter. To the bodies, usually called earths, I have assigned the name of *earthy salifiable bases*, and to the compounds, which are generally denominated metallic oxides, I have applied the expression of *salifiable bases, not alkaline or earthy*.

The arrangement of the acids into five classes has been founded upon the relations of their various bases to oxygen and hydrogen, which bodies are considered as acidifying principles. This arrangement is entirely artificial, and has no other purpose than that of suggesting the composition of the different acid bodies. An account of the principles, which govern it, has been given in a separate chapter in the body of the work.

In treating of the salts, I have thrown them into as many classes, as there are salifiable bases, formed from distinct radicals. If I had adhered to uniformity in the arrangement of these compounds, perhaps I should have considered them in as many sets, as there are salifiable bases themselves. By doing so, however, I should have separated salts, which stand more naturally together. For example, I should have had a class of salts, formed from the protoxide of iron, and another class, formed from the peroxide; but as the salifiable bases, present in these salts, have a common radical, they could not be considered with advantage separately. In distinguishing the different classes of salts, I have never employed the name of the radical, which may furnish the salifiable base or bases, present in them. Hence it is, that, in the following work, the expressions, salts of iron, salts of lead, salts of mercury, &c. never occur. When the chemist speaks of the salts of potash, the expression is strictly correct, and designates all those salts, in which potash is present as a salifiable base. When, however, he speaks of the salts of iron, the mode of expression is devoid of the same precision, and distinguishes the salts, formed from those salifiable bases, which contain iron as their radical. In strict propriety, it is as incorrect to speak of a salt of iron, as it would be to speak of a salt of sodium or a salt of potassium.

This want of uniformity in the nomenclature of salts, however trifling, in its influence, it may be considered by the initiated chemist, is nevertheless a source of considerable embarrassment to the student, who undertakes a course of elementary studies in chemistry for the first time.

Acting under the conviction, therefore, that the mere student in chemistry might be misled from the influence of this erroneous mode of nomenclature, I have endeavoured to overcome the difficulty by adopting a new plan for designating the classes of salts, usually distinguished by the names of the radicals of the salifiable bases present in them. For example, I have appropriated, to the salts formed from the protoxide and peroxide of iron, the title of salts of oxidized iron, instead of the usual one, of salts of iron. The expression, oxidized iron, when thus employed, may be viewed as a generic one, including under its meaning the two distinct oxides of iron. When, however, this mode of expression is used to distinguish salts, formed from salifiable bases, whose radicals furnish but one of these compounds respectively, it should be viewed merely as a more concise appellation, than the adoption of the name of the salifiable base itself would furnish. Thus, although the expression, *salts of the oxide of silver*, is equally correct with that of *salts of oxidized silver*, yet the latter is always preferred.

Although I have, in the manner just explained, deviated from the usual methods of distinguishing particular classes of salts, I have not ventured to make corresponding deviations from the usual nomenclature of the salts themselves.

I have been thus particular in explaining the peculiar mode, which has been adopted in naming certain classes of the salts, as explanations on the point were inadvertently omitted in the body of the work.

The fourth division of compound ponderable bodies has for its title, unsalifiable compounds. Under this head, I have arranged several important substances, which could not stand with propriety in the other divisions of the compound bodies. The epithet unsalifiable, as here applied, although not altogether unexceptionable, is more appropriate than any other which has occurred to me.

Having finished the account of ponderable matter, I proceed to consider the imponderable bodies. Light and heat are the only ones considered. Light occupies but very little attention, as not being a legitimate object of chemical investigation. Heat, however, is treated of much more fully, and, in some respects, in an original manner.

According to the arrangement, which I have adopted, the general principles of chemical action are next considered. Upon this subject, very little has been said; but, perhaps, as much

space has been devoted to the subject, as could with propriety be appropriated to it, without swelling the work to an inconvenient size, or excluding matter of practical importance.

In the second part of the work, the application of the science of chemistry is not made to the examination of all the departments of nature. Mineralogy is too extensive a science, and too remotely connected with the more immediate object of the work, to have permited its introduction with any prospect of advantage. I have, therefore, entirely omitted any chemical examination of minerals. The chemistry of vegetable and animal substances, however, is given, and treated of in the partial manner, as already explained.

While on the subject of the second part of the work, I ought to mention, that I have commenced it with the chemical account of the atmosphere and water. Perhaps these subjects should, more properly, have had a place in the first part; but I was unable to assign to them any position in this part, where they could stand with even tolerable propriety.

The chemical nomenclature of the present work differs, in many respects, from that in general use, and is sometimes indeed peculiar to myself. Whatever may be the defects of the one, which I have adopted, I have, at least, avoided the error of recommending one plan of nomenclature, and adopting another in chemical descriptions. It is certainly due from the sincerity of a chemical writer, that he should be the first to adopt the alterations, which he may suggest. I have adopted a system of chemical terms, from various sources, without regard to their being the ones in current use, under the impression, that it was the most appropriate, which could be used, in the present state of the science. This system of terms, I have uniformly adhered to in chemical descriptions. With regard to the names adopted, which are not in current use in this country, I feel very desirous that some of them should get into general use. I here allude particularly to the chemical names, invented by Gay-Lussac, of hydrochloric acid and hydrocyanic acid, instead of the usual ones of muriatic acid and prussic acid. About the fate of the names, which I have myself proposed, I feel little solicitous. I have, however, been unwilling, that what might otherwise be useful, should be less so, in consequence of my innovations; and, accordingly, I have always introduced the current names (in parentheses) in explanation of the new names. Should, therefore, my suggestions in nomenclature, after being submitted to candid criticism, be deemed injudicious, the comprehension of the facts, detailed in the work, will not be the less easy, from their having been proposed. I have made a similar use of current names, in explanation of all parts of the nomenclature adopted, which are not in familiar use.

To this general account of the work, it is proper to add, that tables have been given of the more important chemical substances. This plan has been pursued with regard to all the undecompounded bodies, and also with regard to the salifiable bases and acids. These tables, I permit myself to believe, will be found useful to the student of chemistry, as well by recapitulating the information contained in the text, as by presenting interesting comparative views of the properties of the different sets of chemical bodies. I have also given a view of the classification pursued of the undecompounded and compound bodies, in the tabular form.

It is proper, before closing this preface, that I should say something on the subject of the sources, from which the present work has been compiled. The great mass of my materials have been derived from the fifth edition of Dr. Thomson's system, published in 1817. This work is the most comprehensive one on chemistry in the English language, and contains an abstract of every thing of importance, which has been done in the science. In preparing the chemical part of the present work, I have availed myself of the information contained in this system, as far as it was applicable to my purpose. Whenever I have found it silent or unsatisfactory on any particular point, I have sought for information elsewhere, and principally in Accum's and Davy's works, and Nicholson's Chemical Dictionary. Occasionally, I have consulted Coxe's edition of Henry's Chemistry. For the pharmaceutical chemistry, and for the notices of the medicinal properties of the various chemical preparations, I am indebted almost exclusively to Coxe's Dispensatory. In compiling the department of the work, devoted to the chemistry of animals, I have occasionally derived my facts from Johnson's Animal Chemistry.

While I have thus compiled the work from the most approved systems of the day, I have not been unmindful, that, meanwhile, the science, of which I was treating, was in a progressive course of improvement. In order, therefore, that it might contain all important discoveries, up to the present time, I have consulted the periodical journals on chemistry. From these sources, I have derived the facts, contained in the sections on selenium and its acid compounds, on cadmium, wodanium, lithia and thorina, on the purpuric and sorbic acids, and on strychnin; and also the notices, which I have given, of the discoveries of Thenard, on the oxidizement of water and the acids. In all these cases, the authority is quoted at the foot of the page.

November, 1819.

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ERRATA.

Page 11, line 22, for *much stronger*, read *not nearly so strong*.
66, 3, *zirconium*, read *zirconia*.
159, 23, *pelatile*, read *petalite*.

A

SYSTEM OF CHEMISTRY

FOR

STUDENTS OF MEDICINE.

IT is proposed, in the present work, to take such a view of the science of Chemistry, as will mark, more particularly, its numerous relations to that of Medicine. Accordingly, while the whole ground which the science embraces will be gone over, so as to make the work complete in itself; those particular portions of it only, the knowledge of which is absolutely essential to the formation of a medical education, will be particularly dilated upon, and the practical details connected with them carefully noted. Plan of the work.

In a complete system of chemistry, the subject naturally divides itself into two parts: one in which the science, strictly so called, is detailed; the other, in which all the substances in nature, within the reach of the chemist, are examined, and the facts connected with them recorded: this second part of the subject has been very properly called a chemical examination of nature. What a complete work embraces.

But in the present work, this arrangement will be considerably modified. In the first part, the science of chemistry, properly so called, will be given complete; but many substances, which have no particular interest for those studying or practising medicine, will be but cursorily noticed; while of others, such as of many of the salts, metals, acids, &c. substances which constitute important parts of the materia medica, the chemical history will be more fully given. In the second part, instead of taking a view of the whole of nature, a chemical examination will be made of the atmosphere and waters of the globe, and of vegetable and animal substances generally, closing with a particular account of the animal chemistry of the human body. In what the present differs from a complete work, and the reason of the difference.

PART I.

SCIENCE OF CHEMISTRY.

With what phenomena the science of chemistry is concerned.

THE science of chemistry is concerned in noticing those actions of matter upon matter, which take place at insensible distances. This branch of knowledge may be very naturally divided into two parts; the first giving a history of the changes produced upon bodies, as consequences of these actions; and the second, detailing the laws by which the actions themselves are regulated. The first part may be called a chemical account of bodies: the second treats of the attraction of aggregation and chemical affinity.

Division of this part of the subject.

The various bodies which are presented to the observation of the chemist differ in a certain particular, which makes it convenient to describe them in two distinct sets. One set are capable of being estimated by weight; the other set, comprising light and heat, are imponderable. The latter, having many common properties, are described with great propriety by themselves; and being more difficult to understand than the ponderable bodies, it is proper to postpone their consideration until the substances which may be estimated by weight have been disposed of.

Agreeable then to the foregoing view of the subject, the science of chemistry, properly so called, will be treated of under the three following heads, forming the subjects of as many books:

I. Ponderable bodies,
II. Imponderable bodies,
III. The general properties of matter upon which chemical changes depend.

BOOK I.

OF PONDERABLE BODIES.

ALL the bodies which are included under this title may be separated into certain constituents, which resist the efforts of further analysis. Although it is demonstrable that simple substances must exist in the nature of things; yet it is by no means certain, that those at present undecompounded are really simple. In fact the large number of such bodies, at present reckoned by chemists, is rather unfavourable to the opinion. These constituents, therefore, of ponderable bodies will be denominated undecompounded bodies; the epithet *undecompounded* expressing the bare fact only that such bodies have never been resolved into simpler constituents.—Now all the ponderable bodies must be either undecompounded, or bodies known to be compound. Accordingly, on this basis, the ponderable bodies will be arranged into two sets under the title of *divisions;* namely,

Book I. Ponderable bodies

are either undecompounded; or known to be compound.

1. Undecompounded ponderable bodies.
2. Compound ponderable bodies.

DIVISION I.

OF UNDECOMPOUNDED PONDERABLE BODIES.

IN conformity with Dr. Thomson's arrangement, these bodies will be divided into

Division of the undecompounded ponderable bodies.

1. Supporters of combustion,
2. Incombustibles,
3. Combustibles.

The substances arranged under each of these heads, will be treated of in the three following chapters.

After the consideration of the undecompounded ponderable bodies has been thus completed, the arrangement of them which has been adopted will be explained and illustrated; and then the theory of definite proportions in chemical combination, and the atomic theory, will be noticed. These two subjects will be given in a fourth and fifth chapter, as they will form a very proper sequel to the chapters employed in describing the chemical bodies included in the present division.

CHAPTER I.

OF UNDECOMPOUNDED SUPPORTERS OF COMBUSTION.

Term *supporter* explained.

The term *supporter* is applied to those bodies, whose presence is absolutely necessary in every case of combustion: the undecompounded supporters are those bodies of this kind which have never been decomposed.

The undecompounded supporters are reckoned as three; they are the following:

1. Oxygen,
2. Chlorine,
3. Iodine.

The substance called fluorine is supposed to have most of the properties of an undecompounded supporter. But its title to a place in this class of chemical bodies is founded, for the most part, upon analogical reasonings; and until its real nature is more accurately developed, it is better, without classing it, to describe its properties, as far as they are known, at the end of the present chapter.

The supporters above enumerated will constitute the subjects of the three following sections.

SECTION I.

OF OXYGEN* GAS.

Dephlogisticated Air of Priestley.

Method of obtaining Oxygen.

I. Oxygen gas may be obtained by the following process: Put into a flask a quantity of the black oxide of manganese†, a substance to be described hereafter, and pour upon it a portion of oil of vitriol, sufficient to form it into a thin paste. Fit to its mouth a glass tube, bent in the shape of the

* From ὀξύτης acidity, and γίγνομαι to generate.

† It is impossible, from the nature of the science of Chemistry, to commence with any part of it, so completely elementary, as not to require the introduction of other parts to aid in explanation. From this fact, it becomes necessary, at the very threshold of the work, to introduce substances to the notice of the reader, of which he is presumed to have no knowledge. This being an inevitable difficulty, the reader is advised, whenever he meets with a new term, to consult the index of the work, in order that he may refer to the chemical substance which such term is intended to convey, and thereby acquire some idea of its nature.

etter S. Adjust the mouth of the tube so as to be in the proper relative position to the pneumatic apparatus*, previously prepared with an inverted jar filled with water. Apply heat to the flask by means of a lamp or candle. An air will be perceived passing up in bubbles into the inverted jar: this air is oxygen gas. CHAP. I.

Explanation of the process. II. The rationale of the formation of oxygen gas by the above process appear to be this; the oil of vitriol does not dissolve easily, the black oxide of manganese; but very readily the green oxide of this substance, which contains only half as much oxygen as the black. Accordingly the oil of vitriol, by its action upon the black oxide, displaces half its oxygen which appears in the gaseous form, and, after being reduced to the state of green oxide, dissolves it.

Discovery. III. Oxygen gas was first obtained by Dr. Priestley in 1774: it was afterwards discovered by Scheele before he had any knowledge of the previous discovery of Priestley.

Properties. IV. Oxygen gas is a colourless and elastic fluid like common air. It is entirely destitute of taste or smell.

Spec. grav. 1·103. V. Bulk for bulk, it is a little more than one and one-tenth times as heavy as atmospheric air.

Oxygen supports flame: VI. Oxygen gas supports flame with greater vividness, and for a longer time than atmospheric air. If a burning body be introduced into a glass vessel containing this gas, its flame is increased exceedingly in brilliancy. The products of combustion in this gas are called *oxides*. It supports respiration, and animals live longer in it than in an equal bulk of atmospheric air. The consideration of its uses, however, both in combustion and in respiration, will be deferred until these subjects come to be treated of particularly. and respiration.

Composes a part of the atmosphere and of water. VII. Oxygen gas is a constituent in atmospheric air, of which it forms in bulk a little more than one-fifth part. It is also a constituent of water, forming eight-ninths of that liquid by weight.

* This apparatus consists of a trough of wood, generally lined with sheet lead or tin, in which a shelf is fitted, about three inches from the top. In the shelf, a hole or slit, about an inch in diameter, is made. When used, the trough is filled with water to about an inch above the surface of the shelf; a glass vessel filled with water and inverted is then placed upon it, over the hole or slit: now if the beak of a retort or the extremity of a glass tube be plunged into the trough, so that its mouth shall be under this opening; any air or gas which may be forced through either, will ascend through the opening in the shelf into the upper part of the vessel, inverted upon it, displacing, at the same time, the water.

In this manner the gases which are not absorbed, or very sparingly so, by water, are preserved. Any gas which is taken up largely by water, is collected by a similar apparatus in which quicksilver is substituted for water.

Book I.
Division I.

SECTION II.

OF CHLORINE* GAS.

Dephlogisticated Muriatic Acid of Scheele;—*Oxygenized Muriatic Acid* of Berthollet.

Method of obtaining chlorine gas.

I. Chlorine gas may be obtained by the following process: Put into a small glass retort a quantity of the black oxide of manganese in powder, and pour upon it a sufficient quantity of the marine acid† of the shops, to convert it into a thin paste. Plunge the beak of the retort into a pneumatic trough, and apply the heat of a lamp to its bottom. A gas is extricated, which may be collected in inverted glass phials, in a manner similar to that described in the last section. The phials may be removed from the trough, and the gas preserved by fitting to their mouths accurately ground stoppers. This gas is chlorine.

Explanation of the process.

II. Chemists have ascertained that the marine acid is a compound of the gas under consideration, and an inflammable air to be described hereafter under the name of hydrogen. In the process just given, the acid and the oxide mutually decompose each other; the chlorine of the former is extricated while its hydrogen combines with the oxygen of the latter.

Chlorine discovered by Scheele;

III. Chlorine gas was discovered by Scheele in 1774. In 1785, Berthollet made a set of experiments upon it, by which he was supposed to have proved it to be a compound of the marine acid and oxygen. In 1809 Gay-Lussac and Thenard published some experiments going to demonstrate that oxygen could not be shown to exist in Berthollet's oxygenized muriatic acid. Sir H. Davy soon after took up the subject, and, in two papers which were published in the Philosophical Transactions for 1810, fully demonstrated that all the experiments which were supposed to indicate the compound nature of oxymuriatic acid, as the gas under consideration was then called, were fallacious; and in fact that it was as yet an undecompounded substance: he accordingly changed its name to chlorine.

true nature made out by Sir H. Davy.

Properties.

IV. Chlorine is in the form of a gas, and possesses the mechanical properties of atmospheric air. Its colour is greenish yellow; its smell, very strong and suffocating, exactly like that produced upon mixing together aqua fortis

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* From χλωρὸς green.

† An acid which may be obtained from common salt by the action of the oil of vitriol, to be described hereafter.

and the marine acid. It destroys all vegetable colours, changing them to white. Chap. I.

V. It is nearly two and a half times as heavy as atmospheric air. Spec. grav. 2·4700.

VI. Chlorine gas supports combustion. Some of the metals, as antimony, arsenic, zinc and iron, take fire spontaneously when plunged into it. The products of these combustions are compounds formed of the burning body and chlorine: they are called by chemists, *chlorides*. Supports combustion

VII. Chlorine gas does not support respiration. An animal forced to breathe it, dies almost instantly. From this it appears, that chlorine, although it agrees with oxygen in supporting combustion, is very different from the latter in being unrespirable. but not respiration.

VIII. Chlorine gas is absorbable by water, with which it forms a liquid having the characteristic properties of the gas itself. When fully saturated, water contains twice its volume of chlorine. Absorbable by water.

IX. Chlorine combines in four proportions with oxygen, and forms compounds, which have been distinguished by the following names: Forms four compounds with oxygen.

1. Protoxide* of Chlorine.
2. Deutoxide of Chlorine.
3. Chloric acid.
4. Perchloric acid.

Chloric and perchloric acids will be described hereafter under the head of acids; the latter under the changed name of *oxychloric acid*. The oxides of chlorine will be noticed this place.

1. *Protoxide of Chlorine* may be obtained by distilling at a gentle heat, the substance formerly called hyperoxymuriate of potash, but at present more properly named chlorate of potash†, mixed with a small proportion of marine acid. A gas is extricated which must be received over mercury. This gas is the protoxide of chlorine. The rationale of its formation is not very obvious. 1. Protoxide of chlorine.

* Oxide is the term applied to all substances of two ingredients, of which oxygen is one, unless such substances have acid, alkaline, or earthy properties. When oxygen combines in two proportions with a body, without the appearance of these properties, the oxides formed are distinguished by the prefixes *proto* or *prot*, abbreviated from πρῶτος first, and *deuto* or *deut*, from δευτερος second; the former being applied to the oxide which contains the least oxygen, the latter to the oxide which contains the most. When a greater number than two oxides of the same substance are to be distinguished, other prefixes derived from the Greek numerals are employed. This mode of distinguishing oxides was devised by Dr. Thomson.

† Chlorate of potash is prepared by passing a current of chlorine gas through a solution of common potash, until the latter becomes saturated. The liquid thus formed, upon standing deposites crystals of chlorate of potash. It is a compound of chloric acid and potash, and will be described hereafter.

Book I. Division I.

2. This gas was discovered in 1811 by Sir H. Davy, by whom it was named euchlorine; but its present name, given by Dr. Thomson, is preferable, being expressive of its composition.

Properties. 3. Protoxide of chlorine has an intensely yellow colour, and a smell resembling that of burnt sugar. It destroys vegetable blue colours, but not until after it has given them a tint of red.

Spec. grav. 2·407. 4. It is somewhat less than two and a half times as heavy as atmospheric air.

5. It is absorbable by water. This liquid when fully saturated, contains eight times its bulk of the gas, and possesses its peculiar colour and smell.

Composition. 6. Protoxide of chlorine is composed of

Chlorine	36
Oxygen	8
	44

2. Deutoxide of chlorine. 1. *Deutoxide of Chlorine* may be obtained by the following process: Take a very small quantity of chlorate of potash (the same substance which is employed in the formation of the protoxide of chlorine) and form it into a dry paste by mixing it with oil of vitriol. Put this paste into a small retort, and immerse its belly in hot water, whose temperature must not be allowed to reach the boiling point. A gas is immediately extricated, which must be collected over mercury. This gas is deutoxide of chlorine.

2. Deutoxide of chlorine was discovered about the same time by Sir H. Davy and Count Von Stadion.

Properties. 3. It has a bright yellowish-green colour, and a peculiar aromatic smell.

Spec. grav. 2·361. 4. It is about two and one-third times as heavy as common air.

5. It exerts no action upon any of the combustibles except phosphorus. This substance, when introduced into it, produces an explosion, and burns with great brilliancy.

6. Water absorbs seven times it bulk of this gas. The solution has a deep yellow colour, and an astringent corrosive taste.

Composition. 7. Deutoxide of chlorine is composed of

Chlorine	36
Oxygen	32
	68

—so it appears that this oxide of chlorine contains four times as much oxygen,

united to the same quantity of chlorine, as the one last described. CHAP. I.

X. The property which chlorine possesses of destroying all vegetable colours, suggested its use to Berthollet as an agent in bleaching. Accordingly it is used extensively for that purpose, wherever bleaching is carried on largely. Chlorine useful in bleaching:

XI. Chlorine is found to be a most efficacious agent in destroying contagion and putrid exhalations of all kinds. It is at present in general use in the anatomical theatres both of Europe and America, and in the naval and military hospitals of Great Britain. and in destroying contagion and putrid miasmata:

In order to prepare this gas for the purpose of destroying contagion or miasmata of any kind; all that is necessary is to mix together two parts of common salt and one of the black oxide of manganese; and to pour upon the mixture two parts of oil of vitriol: the fumes of chlorine immediately arise and are distributed in the infected atmosphere with the effect of destroying the miasmata.

XII. Chlorine gas produces very striking effects upon the human system. When taken internally, or when externally applied in solution by sponging or in the form of a bath, it very soon creates uneasiness in the throat upon swallowing, a redness of the gums, and a burning sensation over the roof of the mouth. These effects are succeeded by the formation of little ulcerated specks, which penetrate the cuticle only, on the inside of the mouth and tongue; but fetid ulcerations, such as are formed by the use of mercury, are never produced. When employed externally the teeth partake of the uneasy feeling of the mouth, but are in no case injured. All these effects are very fugitive, passing away in some cases in a very few days. On the general system it has the effect of quickening the pulse. It appears to act with considerable energy upon the glandular system. and as a remedy.

Of all the glands in the body, it appears to exercise the greatest influence over the liver, increasing the secretion of bile in an eminent degree. It is to Dr. H. Scott particularly that the medical world is indebted for having first pointed out the effects of chlorine in the diseases of the liver. This physician was in the habit of using it as a remedy in the hepatitis of India, which according to him is a mixture of the acute and chronic states of that disease. In such cases he has found chlorine to be equally efficacious with the oxides of mercury, without its use being attended with the disagreeable, and sometimes injurious, effects of the latter remedies. To those cases of derangement of the biliary system, which are accompanied by uneasy nervous feelings, he

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found the use of this supporter particularly suited, by unclogging the vessels of the liver and calming the nervous system.

Dr. Scott compares the remedial powers of chlorine to those of mercury; but attributes to the former the advantage of being harmless as a remedy, even in unskilful hands. It is particularly suited, according to him, to those cases of disease, which appear to require mercury; but which, occurring in peculiar or delicate constitutions, forbid the use of that remedy.

Chlorine is spoken of as a remedy also in syphilis; but the experience of its use in this disease has not been sufficiently diversified to afford conclusions to be depended upon.

Dr. Scott uses the remedy internally; and also externally, in the form of a bath, by sponging, and by immersion of different parts of the body.

Dr. Scott makes his bath of a mixture of equal parts of marine acid and nitrous acid*, diluted with water until its acidity is about equal to that of weak vinegar. He prepares it warm and directs its use once a day, continuing each bathing half an hour.

When used internally, Dr. Scott directs the mixture, rendered very weak by dilution, to be taken in small quantities at a time during the day, using the precaution of washing the mouth after each dose. It is presumed that as much of the mixture may be taken through the course of a day as may be conveniently swallowed.

Water saturated with chlorine was found by Dr. Scott to have the same effects as a remedy as his preparation of mixed acids. This physician therefore does not hesitate to believe that chlorine is the active part of his remedy; and in accordance with this opinion, the same medical properties attributed by Dr. Scott to his acid mixture, have in the present section been assigned to chlorine.†

* An acid to be described hereafter, which, by mixture with marine acid, extricates chlorine.

† See Dr. Scott's paper on the internal and external use of the nitro-muriatic acid in the cure of diseases, from which the above facts are taken; republished in the Med. Recorder, Vol. I. p. 81.

SECTION III.

OF IODINE.*

I. IODINE may be obtained by the following process: Digest a quantity of kelp† in water, until every thing soluble is taken up. Filter the solution and evaporate it until all the common salt, which will fall, has separated in crystals. Boil the residual liquor with a portion of oil of vitriol for some time. Put the liquid thus formed into a small retort, and add as much black oxide of manganese as had previously been employed of oil of vitriol. If heat be applied to the liquid after this addition, a violet coloured vapour arises, which by condensation in a proper receiver is converted into a brilliant solid substance. This substance is iodine. Iodine, how prepared.

II. Iodine was discovered in 1811 by Courtois, a saltpetre manufacturer of Paris. Very little progress, however, was made in the investigation of its properties until the winter of 1813-14, when it received a particular examination from Gay-Lussac and Thenard, and Sir H. Davy. Discovery.

III. Iodine is a solid substance of a greyish black colour, and possessing the metallic lustre. Its smell is similar to that of chlorine but much stronger. Its taste hot, and acrid, leaving a lasting impression on the mouth. Like chlorine it destroys vegetable colours. Properties.

IV. Iodine in the solid form is nearly five times as heavy as an equal bulk of water. In a state of vapour it is more than eight and a half times as heavy as atmospheric air. Its melting point is at the temperature of 224½°. Spec. grav. as a solid 4·948; as vapour 8·678.

V. If a piece of phosphorus be thrown upon a quantity of iodine, the two substances unite rapidly with the evolution of a great deal of heat, but no light is visible. The compounds formed between iodine and combustibles or incombustibles are called iodides. Iodine supports the combustion of several of the combustibles as will be seen hereafter.

VI. Water dissolves not more than $\frac{1}{7000}$th part of its weight of iodine, and acquires an orange yellow colour, and the smell of iodine, but no taste.

VII. Iodine combines in one proportion with oxygen forming iodic acid, and in one proportion with chlorine, forming what has been called the chloriodic acid. The con- Combines with oxygen and chlorine.

* From ἰώδης, violet coloured.

† *Kelp* is ashes of certain sea plants, which are burnt on account of the soda which they yield.

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sideration of these compounds will be defered until the class of acids come to be treated of.

Has no uses.

VIII. Iodine has never been applied to the purposes of medicine. But from the experiments of Orfila, who ascertained it to possess very active, and in large doses, poisonous properties, there is reason to hope that it may become hereafter a very useful article of the materia medica.

SECTION IV.

OF FLUORINE.

Fluorine, the name proposed for the base of the acid of fluor spar;

I. This name has been given by Sir H. Davy to a substance, the existence of which he has rendered very probable, although the body itself has never been obtained in a separate state. It is necessary to notice the reasonings upon which the belief of its existence is founded in this place; as the substance, so far as its nature has been inferred, appears to bear a close resemblance to the supporters.

which there is reason for believing is peculiar in its nature.

II. It is the supposed base of the acid of fluor spar, which it is considered to form in combination with hydrogen. The facts which lead to this opinion of the nature of the acid of fluor spar are strong though not decisive. For example, if this acid, perfectly free from water, is brought in contact with potassium (the metallic base of the vegetable alkali potash) a violent action takes place, hydrogen is emitted, and a solid white substance is formed. Now the inference drawn from this experiment is that the compound formed is made up of a constituent of the acid of fluor spar, unknown in the separate state, and potassium; and that the hydrogen emitted had been previously united to this peculiar radical, constituting the acid. Several experiments of a similar kind to that above stated, have strengthened the supposition that the acid of fluor spar contains a radical of a peculiar nature; but all attempts heretofore made to obtain it in a separate state have proved unsuccessful. These facts are stated merely to give the reader some idea of what is known concerning this hypothetical substance.

CHAPTER II.

OF UNDECOMPOUNDED INCOMBUSTIBLES.

AN incombustible may be defined, a body which is capable, neither of *supporting* combustion, nor of *undergoing* that process. But one undecompounded body, answering to this definition, is known. It is called azote, and will be described in the following section. Definition of an incombustible.

SECTION I.

OF AZOTE.*

* *Nitrogen gas* of Chaptal.—*Phlogisticated air* of Priestley.

I. THIS gas may be obtained by the following process: Put a mixture of iron filings and sulphur, moistened by water, in a small plate, under a glass vessel, containing air and placed over water. Let the apparatus stand in this state for a few days, and it will be found that part of the air has disappeared, and that the space, which it had previously occupied, is filled with water. The air which remains is azote. Azote: how obtained.

II. To understand the above process, it is necessary for the reader to know that atmospheric air is composed of the gas under description and oxygen. By the exposure of a portion of atmospheric air in close vessels to the influence of a moistened mixture of iron filings and sulphur, that part of it which consists of oxygen is absorbed, while its azotic portion remains behind. Process explained.

III. Azotic gas was discovered in 1772, by Dr. Rutherford of Edinburgh. Discovery.

IV. It is a gaseous fluid, having all the mechanical properties of atmospheric air. It has neither taste nor smell. Properties.

V. It is not quite so heavy as atmospheric air, compared with that gaseous fluid, bulk for bulk. Spec. grav. 0·978.

VI. It is not fit to carry on the process of respiration. Animals forced to breathe it die as they would from suffocation. Neither is it fit to support combustion; no combustible substance will burn in it. Unfit to support respiration, or combustion.

* From α privative of, and ζωη life.

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VII. It is scarcely absorbable by water; unless this liquid be freed from the air which it usually contains by boiling; in the latter case it is taken up in small quantity.

Combines with oxygen in 4 proportions

VIII. Azote is capable of uniting with oxygen in five proportions and forms compounds which have received the following names:

1. Protoxide of azote (nitrous oxide)
2. Deutoxide of azote (nitrous gas).
3. Hyponitrous acid.*
4. Nitrous acid.
5. Nitric acid (aqua fortis).

The two first named only of these compounds will be described in this place; the three last, having acid properties, will be described under the head of acids.

1. Protoxide of azote: How prepared.

1. *Protoxide of azote*, the dephlogisticated nitrous gas of Dr. Priestley, may be obtained by the following process: Expose dry nitrate of ammonia† to the heat of a lamp, in a retort adjusted to a mercurial trough. A gas is immediately extricated. This gas is the protoxide of azote.

Discovery.

2. Protoxide of azote was discovered in 1776 by Dr. Priestley.

Spec. grav. 1·52.

3. It has all the mechanical properties of atmospheric air. It is very little more than one and a half times as heavy as common air.

Supports combustion: and produces singular effects when breathed.

4. It supports combustion. Bodies burn in it with nearly the same brilliancy as in oxygen gas. When respired it produces very extraordinary effects, which have some resemblance to those arising from intoxication. Animals forced to breath an atmosphere composed of this gas, die after the lapse of some time.

5. It is absorbable by water. This liquid when fully saturated contains somewhat more than three-fourths of its bulk of the gas.

Composition.

6. Protoxide of azote is composed of

Azote	14
Oxygen	8
	22

* The characteristic termination of the name of an acid compound, is in *ic*. When several acid compounds are formed from the same ingredients united in different proportions, the termination in *ic* distinguishes the name of that one which contains the largest proportion of oxygen; the termination in *ous* is appropriated to the name of the one which contains the next largest quantity. If a third acid compound formed of the same ingredients exist, containing oxygen in a still smaller proportion, the name by which it is known ends in *ous* also, but is distinguished from that of an acid containing oxygen next in degree to the highest, by the prefix *hypo*, derived from the Greek *ὑπο* under.

† A substance to be described hereafter.

7. From the very powerful effects produced by the protoxide of azote when respired, there can be little doubt that it might be used very advantageously in some diseases, by respiration. But although many of the pneumatic medicines produce valuable effects upon the human constitution, yet their expensiveness will always prevent them from coming into general use. CHAP. II.

1. *Deutoxide of azote* or nitrous gas may be obtained by the following process: Pour the aqua fortis of the shops upon a quantity of copper filings placed in a retort. The filings are rapidly dissolved, and a gas is extricated, which may be collected in glass vessels over water. This gas is deutoxide of azote. 2. Deutoxide of azote: how obtained.

2. Aqua fortis is composed of azote united to the largest quantity of oxygen with which it is capable of combining: when poured upon copper filings, part of its oxygen is abstracted, by combining with them, and what remains continuing to be united to the azote, forms the gas in question. Explanation of the process.

3. Deutoxide of azote was accidentally discovered by Dr. Hales, but its properties were first investigated by Priestley. Discovery.

4. It is an invisible and elastic fluid. It is very little heavier than atmospheric air. It supports the combustion of some combustibles, but not of others. A lighted taper introduced into it goes out; sulphur is also extinguished even when introduced burning with a white flame; but it supports the combustion of phosphorus with great brilliancy. Spec. grav. 1·04.

5. When employed in respiration, it proves exceedingly noxious. Animals forced to breathe it become immediately suffocated. Noxious in respiration.

6. Water previously freed from air, absorbs about one-tenth of its bulk of this gas. The solution formed has no taste, and is incapable of reddening vegetable blues.

7. Whenever the deutoxide of azote comes in contact with atmospheric air, the latter is decomposed, and the mixture assumes a yellow colour. The oxygen of the atmospheric air combines with the deutoxide and forms the acid called nitrous acid, which gives rise to the yellow colour just mentioned. If the experiment be made in glass vessels over water, a very considerable condensation will be observed; this arises from the absorbability of the product (nitrous acid) by water. The residual gas after the condensation is complete is azote. The same acid is formed Effects of its mixing with atmospheric air.

when the deutoxide of azote is mixed with oxygen gas in close vessels; but in this case, there is no residual gas.

Composition.

8. Deutoxide of azote is composed of

Azote	14
Oxygen	16
	—
	30

—so it appears that this oxide of azote contains twice as much oxygen as the protoxide last described.

Azote, a constituent in atmospheric air.

IX. Azote in combination with oxygen gas, together with moisture and a very small proportion of carbonic acid, constitutes the atmosphere which surrounds the globe.

The atmosphere will be treated of hereafter in a separate chapter; it is only mentioned in this place incidentally, in order to complete the account of the different combinations of azote and oxygen.

Chloride of azote.

X. Azote has the property of combining with chlorine, and forming a compound called chloride of azote.

How prepared.

1. This chloride may be prepared by the following process: Place a solution, not quite saturated, of nitrate of ammonia in a flat dish. Invert over it a glass jar containing chlorine. The gas is slowly absorbed, and there collects on the surface of the solution an oily substance, which gradually sinks to the bottom: this oily substance is the chloride in question.

Discovery.

2. Chloride of azote was discovered in 1812 by Dulong.

Properties.

3. It is a transparent liquid, of a colour very like that of olive oil. Its smell is strong and peculiar. It is extremely volatile. When exposed to the temperature of 212°, it explodes with prodigious violence. Great caution is necessary in its preparation, owing to the last mentioned property; and, when experimented upon, larger quantities than a grain should not be employed.

Spec. grav. 1.653.

4. Chloride of azote is somewhat more than one and a half times as heavy as water. It is not capable of solution in water; but when it is mixed with that liquid, it is decomposed, its chlorine dissolves, while its azote is liberated.—The composition of this chloride has not been exactly ascertained.

Iodide of azote.

XI. Azote combines in one proportion with iodine, forming the compound called iodide of azote.

Preparation.

1. This iodide may be prepared by putting a quantity of iodine in a solution of ammonia:* the iodine is converted

* Ammonia is the substance which causes the odour of hartshorn. One of its constituents is azote. It will be described hereafter.

into a blackish brown powder, constituting the iodide under consideration. It was discovered by Courtois. Chap. III.

2. It is very volatile; flying off in vapour, without leaving any residuum, when exposed to the open air. It detonates violently when heated, or even when slightly touched, and azote and iodine are formed. The proportion in which its constituents are united is not ascertained. Properties.

XII. The foregoing are all the compounds which azote is capable of forming with the substances already described; its combination with other substances will be mentioned under the heads of such substances respectively.

XIII. Azote has never been applied to any medical or economical use. Azote is applied to no use.

CHAPTER III.

OF UNDECOMPOUNDED COMBUSTIBLES.

By combustibles are meant, bodies whose combination with supporters is attended by the emission of sensible light and heat. In the present chapter it is proposed to treat of those bodies answering to this definition, which have never been resolved into simpler constituents. Definition of a combustible.

The undecompounded combustibles will be divided into four classes, characterized as follows: Undecompounded combustibles divided into

I. Undecompounded combustibles which act the part of an acidifying body. Combustibles of this class will be called *acidifying combustibles*. At present there is but one body known belonging to this class; it is called *hydrogen*. 1. Acidifying combustibles.

II. Undecompounded combustibles which are capable of forming acids, but not salifiable bases, by combining with oxygen. Combustibles of this class are, 1. Carbon; 2. Boron; 3. Phosphorus; 4. Sulphur; 5. Arsenic; 6. Chromium; 7. Molybdenum; 8. Tungsten; 9. Columbium; 10. Selenium. These will be called *acidifiable combustibles*. 2. Acidifiable combustibles.

III. Undecompounded combustibles, which form compounds with oxygen, capable of performing the part of acids or salifiable bases, under different circumstances, in the formation of neutral salts. These are, 1. Antimony; 2. Tellurium. These bodies will be called *intermediate combustibles*. 3. Intermediate combustibles.

IV. Undecompounded combustibles which form salifiable bases, but in no instance acids, by combining with oxygen. Such combustibles will be distinguished by the name *basi-*

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*fiable** *combustibles*. This class will be divided into three sub-classes.

4. Basifiable combustibles; which kind are divided in three sub-classes.

1. Combustibles forming, with oxygen, salifiable bases which have alkaline properties. These will be called *alkalifiable combustibles:* they are, 1. Potassium; 2. Sodium; 3. Lithium; 4. Calcium; 5. Barium; 6. Strontium; 7. Magnesium.

2. Combustibles forming, with oxygen, salifiable bases, which have earthy properties: these are, 1. Yttrium; 2. Glucinum; 3. Aluminum; 4. Zirconium; 5. Thorinum; 6. Silicum.

3. Combustibles forming, with oxygen, salifiable bases, which have neither alkaline nor earthy properties: these are, 1. Iron; 2. Nickel; 3. Cobalt; 4. Manganese; 5. Cerium; 6. Uranium; 7. Zinc; 8. Lead; 9. Tin; 10. Copper; 11. Bismuth; 12. Mercury; 13. Silver; 14. Gold; 15. Platinum; 16. Palladium; 17. Rhodium; 18. Iridium; 19. Osmium; 20. Titanium.

CLASS I.

OF ACIDIFYING COMBUSTIBLES.

Acidifying combustibles.

This class of undecompounded combustibles will be completed by the account of hydrogen in the following section.

SECTION I.

OF HYDROGEN,†

(Formerly called *Light Inflammable Air.*)

Hydrogen; how obtained.

I. Hydrogen may be obtained by the following process: Put one part of iron filings in a retort, having an opening in its upper and convex part, just over the containing cavity: such a retort is called tubulated by chemists. Pour upon the filings two parts of oil of vitriol, previously diluted with four times its bulk of water, through the opening just described, and then close it. A quantity of air immediately rushes out of the mouth of the retort; but being impure by admixture of atmospheric air, must

* I make no apology for forming this adjective to distinguish this class of combustibles. It is sufficient for my purpose that it expresses very well the idea intended to be conveyed, and supersedes the necessity of circumlocution.

† From ὕδωρ water, and γίγνομαι to generate.

not be collected for some moments. As soon as this impure air has passed out, adapt the retort to the pneumatic apparatus, and collect the gaseous product in jars over water. The product is hydrogen gas.

CHAP. III.

II. In explaining this process, it is necessary to inform the reader that water is composed of oxygen and hydrogen chemically combined. Now the water with which the oil of vitriol is diluted is decomposed; its oxygen unites with the iron and forms an oxide, while its hydrogen is evolved. *Process explained.*

III. Some of the properties of this gas were noticed in the last, and even in the seventeenth, century; but very little was known respecting its nature, before Cavendish distinguished it from atmospheric air, and noted most of its properties. *Discovery.*

IV. Hydrogen gas is an invisible and elastic fluid, like common air. When perfectly pure, it is destitute of smell. *Properties.*

V. It is the lightest body at present known; it is about one-fourteenth as heavy as common air. *Spec. grav. ·0732.*

VI. It does not support combustion. All burning bodies are extinguished when plunged into it. *Extinguishes flame,*

VII. Respiration cannot be carried on by its means. Animals forced to breathe it expire as they would from suffocation. *and is unfit for respiration.*

VIII. Hydrogen is not sensibly absorbed by water, unless this liquid be previously freed from air by boiling.

IX. If a lighted taper be brought to the mouth of a phial containing hydrogen, it takes fire, and burns, when pure, with a yellowish white flame. *How it burns.*

X. Hydrogen unites with oxygen in one proportion only, and forms the compound called water. The combination is always attended by combustion; and the heat produced is more intense than that generated by any other substance while undergoing the same process. Taking advantage of this fact, Dr. Hare, of this city, many years ago, contrived an instrument which enables the experimental chemist to avail himself, in his researches, of the intense heat thus generated. This instrument has since been employed in Great Britain without acknowledgment. *Combines with oxygen in one proportion only, and forms water:*

Water is too important a compound to be cursorily described under the head of hydrogen: it will therefore be considered hereafter in a separate chapter. It is proper, however, to notice the proportion in which its constituents combine. It is composed of

Hydrogen	1
Oxygen	8
	9

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with chlorine in one proportion only, forming hydrochloric acid:

XI. Hydrogen combines in one proportion only with chlorine, and forms the marine acid, or, as it is generally called, *muriatic acid.* The compound deserves very particular attention, and will be treated of hereafter, under the name of *hydrochloric acid.*

and with iodine in one proportion, forming hydriodic acid.

XII. It combines also in one proportion with iodine, and forms an acid called hydriodic acid. This compound will be noticed hereafter, under the head of acids.

XIII. By the hypothetical composition of the acid of fluor spar, as has been already mentioned, hydrogen is considered as one of its constituents, existing in a state of combination with a peculiar substance, proposed to be called fluorine. Although the composition of this acid is involved in great doubt, yet the compound itself is of considerable importance, and will be described hereafter under the name of *hydrofluoric acid.*

Combines with azote in one proportion only, forming ammonia.

XIV. Hydrogen combines in one proportion only with azote, and forms the compound called ammonia. It is usually distinguished by the names of hartshorn and volatile alkali. It will receive a separate consideration hereafter.

CLASS II.

ACIDIFIABLE COMBUSTIBLES.

Acidifiable combustibles.

The acidifiable combustibles are: 1. Carbon; 2. Boron; 3. Phosphorus; 4. Sulphur; 5. Arsenic; 6. Chromium; 7. Molybdenum; 8. Tungsten; 9. Columbium; 10. Selenium. These bodies will be noticed in the ten following sections.

SECTION I.

OF CARBON,

(Common name *Charcoal.*)

Charcoal how obtained.

I. Charcoal may be obtained in the following manner: Expose a piece of wood placed in a crucible* and covered with sand, to a red heat for some time. The wood will be converted into the substance called charcoal.

How prepared for the arts.

II. Charcoal is prepared, to be used in the arts, in the following manner: A number of billets of wood, stripped of their bark, and about four feet long and five or six inches thick, are piled on their ends in a conical form. The pile is then covered with clay, except at certain places, through

* A pot made of black lead or earth, in which fusions are generally made.

which the fire is applied. The pile smokes in consequence of the slow combustion which is going on; and in two or three days it is uncovered, and the charcoal raked out of the ashes. Chap. III.

III. Charcoal is a black shining brittle substance, somewhat sonorous when struck; and when pure, destitute of taste or smell. It is insoluble in water, and infusible in the highest heats that can be raised. It is somewhat less than half as heavy as water. Properties. Spec. grav. 0·441.

IV. The diamond chemically considered is nearly the same as charcoal. It is the hardest and most splendent of the precious stones. It has heretofore been found only in India and Brazil. At a mean, it is about three and a half times as heavy as water. Chemically the same with the diamond.

V. When heated to the temperature of 800° in the open air, charcoal combines rapidly with oxygen; the chemical action being attended by all the phenomena of combustion. The product is a gaseous acid, which is called *carbonic acid.* It will be noticed hereafter, under the head of acids. During combustion combines with oxygen; the product, carbonic acid.

VI. Besides carbonic acid, charcoal forms another compound with oxygen. It is in the gaseous form also, and is called *carbonic oxide.* Combines with a less dose of oxygen, forming carbonic oxide:

1. Carbonic oxide may be obtained in the following manner: Expose a mixture of equal parts of iron filings and chalk, made as dry as possible, in an iron retort, to a red heat. A great quantity of gas is extricated. Agitate the gaseous product with lime-water, which absorbs a part of it: the residue is carbonic oxide.

2. In explaining this process, it is necessary to inform the reader, that chalk is a compound of carbonic acid and lime. Now carbonic oxide contains less oxygen than carbonic acid. In consequence of the heat to which the mixture is exposed, the filings are capable of abstracting a portion of oxygen from the carbonic acid of the chalk; whereby the acid is reduced to the state of carbonic oxide. The oxide, however, is not extricated pure by the above process; it always has mixed with it a portion of carbonic acid. This is removed by the agitation with lime-water, by which it is absorbed.

3. Dr. Priestley was the first chemist who distinguished carbonic oxide as a peculiar gas; but Cruickshanks first ascertained its real composition. Discovery.

4. Carbonic oxide is an invisible and elastic fluid like atmospheric air; and very nearly of the same weight. Properties. Spec. grav. 0·956.

5. It is capable of undergoing combustion. When set on fire, it burns with a lambent blue flame, emitting very little light. During the combustion it combines with an

Book I. Division I. additional dose of oxygen, and the product is carbonic acid.

Unfit to be respired. 6. It is unfit for supporting respiration. Animals placed in an atmosphere of this gas, drop down dead almost instantly.

Combines with chlorine and forms an acid. 7. Carbonic oxide has the property of combining with chlorine, and forms a compound, having acid properties. It will be described hereafter under the name of *chloro-carbonic acid*.

Forms a gaseous compound with hydrogen. 8. Carbonic oxide is capable of forming a gaseous compound with hydrogen. This gas was lately discovered by Dr. Thomson while experimenting upon the ferrocyanate of potash, commonly called triple prussiate of potash. It is formed by the action of oil of vitriol upon the above mentioned substance by the assistance of heat. It has a peculiar, but not a disagreeable smell, and an aromatic taste, attended by a hot impression upon the mouth, which continues for some time. It is not absorbable by water. It burns readily, when brought in contact with a candle, with a deep blue flame. It is very little lighter than atmospheric air.*

Composition. 9. Carbonic oxide is composed of

Carbon	6
Oxygen	8
	14

Carbon combines with azote and forms cyanogen: how obtained. VII. Carbon combines with azote and forms the compound called cyanogen.

1. Cyanogen may be obtained by exposing the substance usually called prussiate of mercury,† in a dry state, to a heat rather under redness, in a small retort. It blackens, and a gas is extricated which must be collected over mercury. This gas is cyanogen.

Discovery. 2. Cyanogen was discovered in 1815, by Gay Lussac.

Properties. 3. It is an invisible and elastic fluid like common air. Its smell is peculiar, strong and disagreeable. It is about one and four-fifth times as heavy as common air.

Spec. grav. 1·80.

Both a supporter and a combustible. 4. Although a compound of an incombustible and a combustible, this gas is nevertheless a supporter of combustion. It supports the combustion of potassium. On the other hand it is a combustible. The products of its combustion are carbonic acid and azote.

5. It possesses the singular property of combining with

* See a paper by Dr. Thomson, on triple prussiate of potash. Annals of Philosophy, xii. 102.

† This substance will be noticed hereafter.

several combustibles, and even with some salifiable bases, without undergoing decomposition. These compounds, when they do not possess acid properties, are called cyanodides. Some of them will be noticed hereafter. CHAP. III. Forms cyanodides.

6. Cyanogen is composed of

Carbon	12
Azote	14
	26

VIII. Carbon combines with hydrogen in two proportions, and forms compounds, which have been named by Dr. Thomson hydroguret of carbon and bihydroguret of carbon. Carbon forms two compounds with hydrogen.

1. Hydroguret of carbon, formerly called olefiant gas, may be obtained by applying the heat of a lamp to a mixture of four parts of oil of vitriol and one part of strong spirit of wine: the gas in question is immediately disengaged, and may be collected in jars over water. 1. Hydroguret of carbon.

2. This gas was discovered in 1796, by the associated Dutch chemists. Discovery.

3. It is an invisible and elastic fluid, destitute of taste or smell. It is very little lighter than common air. It burns with splendour, the products being carbonic acid and water. It is absorbable by water, which liquid when saturated contains one-tenth of its bulk of the gas. Properties. Spec. grav. 0·9745.

4. Hydroguret of carbon combines with chlorine, and forms a compound which Dr. Thomson proposes to call *chloric ether*. It may be obtained by making a current of the two gases meet in a large glass receiver. A chemical union immediately takes place, and the compound in question collects at the bottom of the receiver. It is a limpid and colourless liquid like water, possessing a peculiar sharp sweetish agreeable taste, and in smell resembling the ether formed from hydrochloric acid (marine acid). It is a little more than one and one-fifth times as heavy as water. It burns with a green flame, vapours of hydrochloric acid (marine acid or muriatic acid) being formed, together with much soot. When passed through a red hot porcelain tube it is decomposed into hydrochloric acid, and a gas composed of hydrogen and carbon; while charcoal is deposited. Combines with chlorine, forming chloric ether. Spec. grav. 1·2201.

5. Hydroguret of carbon is composed of Composition of the hydroguret.

Carbon	6
Hydrogen	1
	7

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2. Bihydroguret: how obtained.

1. Bihydroguret of carbon, usually called carburetted hydrogen, may be obtained in the following manner: Attach a piece of wood to an inverted glass jar in such a way as to cause it to float on water with its mouth a little below the surface; being at the same time filled with water. Place the glass jar thus prepared upon the surface of a stagnant pond, and stir up the mud at the bottom, just under its mouth; a number of air bubbles will ascend into the jar and displace the water. This gas, after being washed with lime-water to separate carbonic acid, is pure bihydroguret of carbon.

The same as the fire-damp.

2. Bihydroguret of carbon is the gas which forms in coal-mines, distinguished by the name of fire-damp, and which has occasioned such fatal consequences to miners by its explosions.

Spec. grav. 0·555.

3. Bihydroguret of carbon is an invisible and elastic fluid, destitute of taste or smell. It is somewhat more than half as heavy as common air. When set on fire, it burns with a yellow flame; the products of the combustion are water and carbonic acid.

Composition.

4. It is composed of

Carbon	6
Hydrogen	2
	8

—so that it appears that this gas contains twice as much hydrogen as the simple hydroguret; and hence the reason that it is distinguished from the latter by the prefix *bi*, contracted from the Latin word *bis*, twice.

Nature of heavy inflammable gas.

IX. The inflammable gases, which are obtained by the distillation of moist charcoal, pit-coal, or wood, are found to be mixtures, in different proportions, of hydrogen, hydroguret and bihydroguret of carbon, and carbonic oxide. From the constituents of these gases varying continually, according to the substances from which the distillation is made, the degree of heat, and the stage of the process at which they may be collected, there is reason to believe that none of them are chemical compounds, but chemical mixtures only.

X. The gas obtained from pit-coal and from tar is now employed both in Europe and America for the purposes of illumination. Dr. Thomson ascribes the merit of the suggestion of gas-lighting to Mr. Murdoch of Birmingham. The gas from pit-coal is found to be a compound of hydroguret and bihydroguret of carbon mixed with carbonic oxide.

XI. Charcoal has been used with several views in medicine. At one time it was given internally in consumption as a deoxidizing remedy, under the influence of the theory, that this disease depended upon the superoxygenation of the blood. It has been recommended very highly for the cure of intermittent fever. Its antiseptic powers make it a proper ingredient in poultices for gangrene, and sloughing or fetid ulcers. The same power renders it one of the best tooth powders that can be used, more especially for carious teeth.

Chap. III. Medical uses of charcoal.

SECTION II.

OF BORON.

I. Boron may be obtained by the following process: Expose equal parts of boracic acid,* obtained as pure as possible, and potassium, placed alternately in a copper tube, for some minutes, to an obscure red heat, in a small furnace. Upon withdrawing the heat, there is found in the tube an earthy looking matter, which must be treated with water, until every thing soluble be taken up: the residue, after being washed repeatedly, until the water comes off unaltered, is to be dried in a capsule at a moderate heat: it is now pure boron.

Boron; how obtained.

II. Boracic acid is a compound of the substance under description and oxygen. Potassium is an ingredient in the vegetable alkali potash, and is found to have a very strong tendency to combine with oxygen. Now this substance combines with the oxygen of part of the boracic acid, and becomes converted into pure potash; while the peculiar substance called boron is liberated from combination. Part of the potash formed remains pure, and part combines with the boracic acid not yet decomposed, forming the compound called borate of potash. Upon washing the product, these latter substances, being soluble, are removed; and what remains when dried is pure boron.

Explanation of the process.

III. Although Sir H. Davy had reason to believe that he had decomposed the boracic acid, when he exposed it to the action of galvanic electricity in 1807; yet the discovery of boron belongs to Gay-Lussac and Thenard, who were the first chemists who put its existence beyond doubt, by decomposing boracic acid, and afterwards recomposing it from its constituents.

Discovery.

* Boracic acid is a sour substance obtained by decomposing borax.

Properties.

IV. Boron is a brownish-green solid, destitute of taste, and producing no effect upon vegetable blues. It is infusible and not volatilizable at a very intense heat. It is insoluble in water, alcohol (strong spirit of wine), ether or the oils, whether hot or cold. Its specific gravity has not been accurately ascertained.

Phenomena attendant on its combustion:

V. Upon exposure to a cherry red heat in the open air, boron takes fire, and burns for some time. Its surface, by the absorption of oxygen, is converted into boracic acid, which vitrifies by the heat, and thereby puts a stop to the combustion. The crust of acid thus formed may be dissolved off, and what remains is boron, not yet acted upon. By alternate combustions and solutions, the whole of the boron may be converted into boracic acid. From this statement the inference may be drawn, that boron, during combustion, combines with oxygen and forms boracic acid. The account of this acid will be deferred until the class of acids come under consideration.

product, an acid.

Combustion in chlorine uncertain.

VI. According to Gay-Lussac and Thenard, boron does not burn in perfectly dry chlorine; but according to Sir H. Davy, it burns in this supporter with a brilliant white flame.

It combines with fluorine, and forms an acid.

VII. Boron combines with the radical of the acid of fluor spar, or fluorine, and forms an acid compound, which will be treated of under the head of acids.

SECTION III.

OF PHOSPHORUS.

Phosphorus; how obtained.

I. Phosphorus may be obtained by the following process: Mix 100 parts of calcined or burnt bones, reduced to fine powder, and diluted with four times their weight of water, with 40 parts of oil of vitriol, in a porcelain or stoneware basin: the mixture grows hot, and a number of air-bubbles escape. Stir the mixture occasionally, and at the end of twenty-four hours, pass it through a filter of linen cloth. Calcined bones are composed of a sour compound (consisting of phosphorus and oxygen, and called phosphoric acid) united with lime. The oil of vitriol, by its action, has the effect of detaching from combination with the phosphoric acid, nearly all the lime; with which it forms a compound, which renders the mixture turbid, it being of an insoluble nature. By throwing the whole upon a linen filter, the

insoluble compound is retained, while a transparent liquid, consisting of phosphoric acid combined with a small portion of lime and dissolved in water, passes through. The next step in the process is to add gradually to the liquid thus obtained, a solution of the nitrate of lead (a compound of nitric acid (aqua fortis) and oxide of lead) as long as any white powder is thrown down: the consequence of this addition is, that the nitric acid combines with the lime, which it holds in solution; while the oxide of lead unites with the phosphoric acid, and falls in the form of an insoluble powder. This insoluble compound of phosphoric acid and oxide of lead, called by the chemists *phosphate of lead*, must be separated by the filter, washed, and dried. Then mix it with one-eighth of its weight of charcoal powder, and expose it gradually, by means of a furnace, to a white heat in an earthenware retort, whose beak is plunged under water. For some time bubbles of air, which occasionally inflame, break from the surface of the water; at a particular temperature, the phosphate of lead becomes decomposed; the charcoal abstracts all the oxygen which it contains, and flies off in the form of carbonic acid;* so that nothing is left but lead and phosphorus. The lead remains in the retort in a state of fusion, while the phosphorus is driven forward in the state of vapour, and drops from its beak into the water.

Its discovery and history.

II. Phosphorus was accidentally discovered by Brandt, a chemist of Hamburgh, in 1669, while attempting to extract from human urine a substance capable of converting silver into gold. In 1674, it was again discovered by Kunkle, a German chemist, although all he knew of Brandt's process was the animal fluid which was employed in it.

Boyle, by his own account, also discovered phosphorus, and communicated his process to his assistant, Godfrey Hankwitz, a London apothecary, who continued for many years to supply all Europe with this substance.

In 1737, a person appeared in Paris who asserted that he could make phosphorus. Several members of the French academy witnessed his process, for communicating which he was rewarded by the French government. It was a very tedious one, consisting in evaporating putrid urine, and produced only small quantities of phosphorus at a time.

Soon after this period, Margraff published a more expeditious process for obtaining phosphorus, which consisted in mixing inspissated urine with a salt of lead. In this way

* The reader is presumed to know the constituents of carbonic acid, they having been given under the head of Charcoal, p. 21.

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he proved that urine contained a substance, which, when mixed with charcoal, produced phosphorus.

Exists in bones.

The next step in the investigation of phosphorus was the discovery of its existence in bones, made by Gahn. This was followed by Scheele's inventing a process by which phosphorus might be obtained from these animal substances.

Properties.

III. Phosphorus is a white substance; and, when perfectly pure, is transparent and nearly colourless; but as usually procured, it is of a bright amber colour, and semi-transparent. After having been kept for some time under water, it assumes the appearance of white wax. When heated to the temperature of 148°, it takes fire, burning with a very bright flame. By combustion in atmospheric air or oxygen gas, it is converted into an acid compound called phosphoric acid. By mere exposure to the air, it undergoes a kind of slow combustion; and an acid compound is formed, which is now generally considered to be a mixture of phosphoric acid, and another acid of phosphorus called phosphorous acid.

Spec. grav. 1·770.

IV. Phosphorus is a little more than one and three-fourth times as heavy as water. Its melting point is at the temperature of 108°. When air is excluded, it evaporates at 219°, and boils at 554°.

Combines with oxygen in four proportions.

V. Phosphorus combines with oxygen in four proportions, and forms compounds which are distinguished by the following names:

Oxide of phosphorus.
Hypophosphorous acid.
Phosphorous acid.
Phosphoric acid.

The three last mentioned compounds being acids, their description will be deferred until the class of acids come to be treated of. The oxide of phosphorus will be noticed in this place.

Oxide of phosphorus: how obtained.

1. Oxide of phosphorus may be obtained in the following manner: Expose a small quantity of phosphorus to the heat of boiling water in a long narrow tube; a white vapour arises, and condenses on the inside of the tube: this constitutes the oxide in question. It contains less oxygen than the acid compounds of phosphorus and oxygen: its properties have not been ascertained.

Phosphorus forms two compounds with chlorine.

VI. Phosphorus combines in two proportions with chlorine, and forms compounds distinguished by the names of protochloride and perchloride of phosphorus.

1. Protochloride: how obtained.

1. *Protochloride of phosphorus* is obtained by passing the vapour of phosphorus through heated corrosive sublimate (a compound of chlorine and mercury) in a glass or

porcelain tube, to one end of which a receiver is luted. A liquid collects in the receiver, which consists of this protochloride. *Chap. III.*

2. This chloride was first made in quantities and examined by Gay-Lussac and Thenard; but its real constituents were first demonstrated by Sir H. Davy. *Discovery.*

3. Protochloride of phosphorus is a colourless liquid, of an acid and very caustic taste. It smokes strongly in the open air; but in close vessels it remains unaltered. When dropped into water, this liquid is decomposed, and its constituents uniting to the constituents of the chloride, form hydrochloric (muriatic) acid, and phosphorous acid. It is nearly one and a half times as heavy as water. *Properties.* *Spec. grav. 1·45.*

4. Protochloride of phosphorus is composed of *Composition.*

Phosphorus	12
Chlorine	43* (nearly)
	—
	55

1. *Perchloride of phosphorus* may be obtained by burning phosphorus in dry chlorine gas. *2. Perchloride: how obtained.*

2. It is an exceedingly volatile substance of a snow-white colour. Its vapour reddens litmus paper; from which it would appear that it possesses acid properties. It decomposes water with great energy, and combines with its constituents in such a way as to form hydrochloric (muriatic) acid, and the phosphoric acid. Although a product of combustion, it is still capable of undergoing that process; when in the form of vapour, it burns, when lighted, in the open air. *Properties.*

3. Perchloride of phosphorus is composed of *Composition.*

Phosphorus	12
Chlorine	80*
	—
	92.

—So that it appears that this chloride contains somewhat less than twice as much chlorine as the protochloride.

VII. Phosphorus combines in two proportions with iodine, and forms the compounds called by Dr. Thomson, protiodide and periodide of phosphorus. These iodides were first noticed by Sir H. Davy; but Gay-Lussac was the first chemist who subjected them to an accurate examination. *Phosphorus forms two compounds with iodine.*

1. *Protiodide of phosphorus* may be formed by mixing *1. Protiodide: how formed.*

* The above analysis does not accord with the theory of definite proportions. Hereafter every analysis, which is at variance with this theory, until the reader is made acquainted with it, will be distinguished by an asterisk. This mark of distinction the reader will find convenient when he comes to apply the theory.

together in a glass tube, 1 part of phosphorus, and 10·41 parts of iodine; the combination takes place rapidly with the evolution of much heat, but no light.

Properties. 2. It is a solid substance of a reddish-brown colour. Its melting point is at the temperature of 212°. When thrown into water, it decomposes that liquid, and at the same time is converted into hydriodic acid and phosphoric acid.

Composition. 3. Protiodide of phosphorus is composed of

Phosphorus	12
Iodine	125
	137

2. Periodide: how obtained. 1. *Periodide of phosphorus* may be prepared by mixing together 1 part of phosphorus and 20·82 parts of iodine; they combine with violence and with the evolution of a great deal of heat.

Properties. 2. It is a solid substance of a black colour. Its melting point is at the temperature of 115°. It dissolves in water with the evolution of much heat; being at the same time decomposed.

Composition. 3. Periodide of phosphorus is composed of

Phosphorus	12
Iodine	250
	262

—so that it appears that the periodide contains exactly twice as much iodine as the protiodide.

Phosphorus dissolves in azote. VIII. Phosphorus dissolves in small proportion in azote. The combination is attended by a small increase of bulk.

Effects of protoxide of azote on it; IX. Phosphorus may be melted and sublimed in protoxide of azote (nitrous oxide) or even touched while in that gas with a red hot iron, without alteration; but if a wire heated to whiteness, be presented to the phosphorus, it takes fire and explodes; the products being azotic gas, and nitric and phosphoric acids.

and of chloride of azote. X. Phosphorus, brought in contact with chloride of azote, explodes violently. It has not been possible to collect the products.

Forms two compounds with hydrogen. XI. Phosphorus combines in two proportions with hydrogen, and forms compounds, which Dr. Thomson calls hydroguret and bihydroguret of phosphorus.

1. Hydroguret of phosphorus how obtained. 1. *Hydroguret of phosphorus*, or phosphuretted hydrogen as it is usually called, may be obtained in the following manner: Throw into a small retort, filled with water acidulated with hydrochloric (muriatic) acid, a portion of the compound formed of phosphorus and lime, which has been

carefully secluded from the air; a quantity of gas is immediately extricated, which must be collected over water. This gas is the hydroguret of phosphorus. CHAP. III.

2. Hydroguret of phosphorus was discovered in 1783 by Gengembre, while heating a mixture of liquid potash and phosphorus in a small retort. Discovery.

3. It is in the form of a colourless and elastic fluid. Its smell is similar to that of onions; its taste exceedingly bitter. It is somewhat lighter than atmospheric air. When it comes in contact with common air, it takes fire spontaneously and burns with great splendour. In chlorine gas it burns with a greenish yellow flame; the products being hydrochloric (muriatic) acid and chloride of phosphorus. Water saturated with it contains rather more than two per cent.; and acquires a yellow colour, an intensely bitter taste, and a smell similar to that of the gas. Properties. Spec. grav. 0·9022.

4. Hydroguret of phosphorus is composed of Composition.

Phosphorus	12
Hydrogen	1
	13

1. *Bihydroguret of phosphorus* may be obtained by exposing hydroguret of phosphorus to the action of the direct rays of the sun: phosphorus is thereby deposited and the gas is converted into this hydroguret. Bihydroguret; how obtained.

2. Bihydroguret of phosphorus was first particularly examined in 1812, by Sir H. Davy, by whom it was obtained by exposing crystallized phosphorous acid to heat.

3. It is in the form of a colourless and elastic fluid. Its smell is similar to that of hydroguret of phosphorus, but not so disagreeable. It is very nearly as heavy as atmospheric air. It does not burn spontaneously in atmospheric air or oxygen gas; but when heated to the temperature of 300° in either of them it explodes, the products being water and phosphoric acid. When mixed with chlorine, a spontaneous combustion takes place, attended with a white flame. The products are hydrochloric (muriatic) acid and chloride of phosphorus. It is absorbable by water, which when saturated contains one-eight of its bulk of the gas. Properties.

4. Bihydroguret of phosphorus is composed of Composition.

Phosphorus	12
Hydrogen	2
	14.

—So that it appears that the bihydroguret contains twice as much hydrogen as the hydroguret.

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Existence denied by Dalton.

5. Mr. Dalton does not admit of the existence of this hydroguret. This chemist considers that there is but one combination of phosphorus and hydrogen; and that, the one which has just been described under the name of hydroguret of phosphorus; that when it is obtained from phosphuret of lime, which has been exposed even for a few hours to the atmosphere, it is liable to be more or less contaminated with free hydrogen; and that the bihydroguret of phosphorus is hydroguret of phosphorus, mixed with a variable quantity of free hydrogen.*

Combustion of phosphorus:

XII. Phosphorus is a very combustible substance. When heated to the temperature of 148°, in the open air, it combines rapidly with oxygen; the action being attended by a vivid combustion. Under such circumstances, phosphorus combines with the largest dose of oxygen with which it is capable of uniting, and forms the acid called phosphoric acid, already mentioned.

product, phosphoric acid.

Medical properties of phosphorus.

XIII. Phosphorus has never been used extensively in medicine; and yet, from its active properties, there is reason to believe, that it might be very useful in many cases of disease. When taken in the dose of from one-eighth to one-fourth of a grain, rubbed up with some mucilage of gum arabic, it produces great heat about the stomach, and occasionally violent purging. It has been used in France, as well as in this country, as a stimulant in low fevers; but it would appear that the success was not very encouraging. In debility of the sexual organs, it it said to have been used with advantage.

The effects of this substance upon the system deserve to be particularly investigated. It is not important to know in what diseases it has been tried; but if a complete history of its effects was made out, it would enable practitioners to know what results they had a right to expect from it, and to use it accordingly.

SECTION IV.

OF SULPHUR,

(Commonly called *Brimstone.*)

Sulphur: how obtained.

I. Sulphur may be easily obtained by distilling the mineral called pyrites.† It rises in a state of vapour, and may be made to deposite in proper receivers. In this state it is called flowers of sulphur.

* See Dalton on Phosphuretted Hydrogen. Thomson's Annals, xi. 7.

† Metallic combinations, containing a very large proportion of sulphur.

II. Sulphur is found native abundantly, especially in the neighbourhood of volcanoes.

Properties. III. It is a hard brittle substance of a greenish yellow colour, without any smell, but possessing a weak taste. It remains unchanged in the open air, and is insoluble in water.

Spec. grav. 1·990. IV. It is nearly twice as heavy as water. Its melting point is at the temperature of 218°.

Its combustion described: V. When heated in the open air to the temperature of 560°, a rapid combination with oxygen takes place, attended by all the phenomena of combustion; while at the same time, fumes of a suffocating odour are emitted. The flame is of a pale blue colour. If the combustion be performed in pure oxygen, the product is found to be an acid, which is called by chemists the sulphurous acid. (product an acid.) Besides this acid formed by combustion, sulphur forms with oxygen two other acids, which are called hyposulphurous and sulphuric acids. The last mentioned acid, in common language, is called oil of vitriol. These acid compounds will be described hereafter under the head of acids.

Forms one compound with chlorine. VI. Sulphur combines in one proportion with chlorine, and forms chloride of sulphur.

Chloride of sulphur; how obtained. 1. Chloride of sulphur may be obtained by passing a current of chlorine through flowers of sulphur; or by heating sulphur in a dry glass vessel containing chlorine.

Properties. 2. It is in the form of a liquid, of a brownish red colour or of a yellowish green, according as it is viewed by reflected or transmitted light. Its smell is strong and somewhat similar to that of sea plants. Its taste is acid, hot and bitter, affecting the throat with a painful tickling. It smokes very much in the open air; and the eyes when exposed to its vapour, become filled with tears, and are affected with that smarting sensation, produced by smoke. It changes the colour of moist litmus paper to red. It is about one and three-fourth times as heavy as water. (Spec. grav. 1·7.)

Composition. 3. Chloride of sulphur is composed of

Sulphur	16
Chlorine	36
	52

Forms one compound with iodine. VII. Sulphur combines in one proportion with iodine, and forms iodide of sulphur.

1. Iodide of sulphur may be easily formed by mixing together its constituents, and exposing them to a heat sufficient to melt the sulphur.

2. It is of a greyish black colour, and radiated structure. It was first described by Gay-Lussac.

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Sulphur forms two compounds with hydrogen; which are analogous to acids:

VIII. Sulphur combines in two proportions with hydrogen, and forms compounds, which are generally known by the names of supersulphuretted hydrogen, and sulphuretted hydrogen. Sulphuretted hydrogen possesses all the properties of an acid; while the supersulphuretted hydrogen has the characteristic property of that class of chemical bodies, in as much as it forms compounds analogous to salts with salifiable bases. Both these compounds will be described among the acids, under the names of hydrosulphurous and hydrosulphuric acids.

and one compound with carbon.

IX. Sulphur combines with carbon, and forms the compound called sulphuret of carbon.

Sulphuret of carbon; how obtained.

1. Sulphuret of carbon may be obtained by the following process: Place a porcelain tube, filled with charcoal, through a furnace, fixed in an inclined position. Lute to its lower extremity a glass tube of such a shape that it may be passed into a bottle of water; to the other end, lute another glass tube, containing bits of sulphur, and furnished with a wire fixed in such a way as to admit of being used to push the sulphur forward, without admitting the air. Heat the charcoal to redness, and continue it at that temperature, until bubbles of air cease to be disengaged; then push the sulphur by means of the wire into the porcelain tube. A substance will pass into the bottle and condense under the water: this substance is the sulphuret of carbon.

Properties.

2. Sulphuret of carbon is a transparent and colourless liquid, of an acrid, pungent and somewhat aromatic taste; and nauseous, fetid, and quite peculiar smell. It is one of the most volatile liquids known. It was first obtained in 1796 by Lampadius, upon distilling a mixture of pyrites and sulphur. This chemist supposed it to be a compound of sulphur and hydrogen. It is somewhat more than one and one-fourth times as heavy as water. Its boiling point is between the temperature of 105° and 110°. It does not congeal when cooled down to — 60°. It produces a greater cold by its evaporation, than any other substance known. The mercury in a thermometer, whose bulb is enveloped in fine lint wetted by it, sinks from 60° to about zero. In a receiver of an air pump, which is rapidly exhausted of air, a thermometer under the same circumstances sinks to — 82° in the course of a few minutes. When raised to a certain temperature in the open air, it burns with a blue flame: the products being sulphurous acid, carbonic oxide and carbonic acid.

Spec. grav. 1·272.

3. Sulphuret of carbon is composed of — Composition.

Sulphur	32
Carbon	6
	38

X. Sulphur combines with phosphorus, and forms sulphuret of phosphorus. This sulphuret is readily formed by melting its constituents together under water. The heat must be applied cautiously. The constituents of this sulphuret unite in various proportions. — Sulphur combines with phosphorus.

XI. Sulphur furnishes the physician with a very valuable laxative. It appears particularly suited for hæmorrhoidal affections. In psora, when mixed with some mild ointment, it constitutes one of the best external applications. — Sulphur, used in medicine.

SECTION V.

OF ARSENIC.

I. Arsenic may be obtained pure by the following process: Expose a mixture of two parts of white arsenic (a compound of oxygen and arsenic) with one part of black flux,* to a gentle heat; the flux separates the oxygen from the white arsenic, which is thereby reduced to a state of purity, and then slowly sublimes. — Arsenic; how obtained.

II. Arsenic, generally combined with sulphur or oxygen, is found principally in Germany. It has been found in some parts of the United States; combined with iron near Boston; with nickel in Maryland; and with cobalt in Connecticut.† — Where found.

III. It is a metallic substance of a bluish white colour and considerable brilliancy. When cold it has no smell; but when heated it emits an odour resembling that of garlic. It is the softest of all the metals; and so brittle that it may be reduced to powder in a mortar. When exposed to the air, it loses its lustre, turns black and falls to powder; but under water it remains unaltered. — Properties.

IV. It is somewhat less than eight and one-third times as heavy as water. Its fusing point is not known, in consequence of its subliming before fusion. — Spec. grav. 8·31.

* Flux is a term applied to substances, used by chemists to facilitate the fusion of metals, or the reduction, to the metallic state, of metallic ores. The black flux is made by detonating one part of nitre and two parts of tartar together in an ignited crucible.

† See Cleaveland's Mineralogy.

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V. Arsenic burns with a pale blue flame. The product of the combustion is an acid.

Forms two acid compounds with oxygen.

VI. Arsenic combines in two proportions with oxygen, and forms compounds having acid properties. They are called by chemists the arsenious acid and arsenic acid. The former is that which is formed during combustion; they will be described hereafter under the head of acids.

Forms one compound with chlorine.

VII. Arsenic combines in one proportion with chlorine, and forms chloride of arsenic.

Chloride of arsenic; how obtained.

1. Chloride of arsenic, formerly called butter of arsenic, may be obtained by distilling a mixture of six parts of corrosive sublimate (a chloride of mercury) and one part of arsenic, with a gentle heat; the chloride in question passes over, and may be collected in a receiver.

Properties.

2. Chloride of arsenic is a volatile transparent liquid of the consistence of oil. It is decomposed by being mixed with water; arsenious acid being precipitated.

Arsenic combines with iodine,

VIII. Arsenic combines with iodine and forms iodide of arsenic. It may be prepared by bringing its constituents into contact, whereupon they unite readily. This iodide is of a dark purple red colour. It possesses acid properties.

and with hydrogen.

IX. Arsenic has the property of combining with hydrogen, and forms the compound called arsenuretted hydrogen.

Arsenuretted hydrogen; how obtained.

1. Arsenuretted hydrogen may be obtained very readily by pouring sulphuric acid (oil of vitriol) diluted with twice its weight of water, upon a mixture of four parts of zinc and one of arsenic: a gas is immediately extricated. This gas is arsenuretted hydrogen. It becomes formed in consequence of the decomposition of water; the hydrogen of that liquid, just at the moment of its formation, comes in contact with the arsenic and dissolves it in minute proportion.

Properties.

2. Arsenuretted hydrogen is a colourless and elastic fluid like common air. Its smell is nauseous. When drawn into the lungs it produces very deleterious effects. It is capable of combustion. When set on fire, it burns with a blue flame. It was discovered by Scheele during his experiments upon arsenic.

Arsenic combines with phosphorus;

X. Arsenic has the property of combining with phosphorus, forming the compound called phosphuret of arsenic. It may be obtained by distilling a mixture of equal parts of its constituents over a moderate fire. This compound has a brilliant appearance and a black colour. It requires to be kept under water for preservation.

and with sulphur.

XI. Arsenic combines with sulphur and forms sulphuret of arsenic.

Sulphuret of arsenic.

1. This sulphuret may be obtained by melting together its constituents in a covered crucible. When thus formed

it is usually called realgar, and is a solid substance of a scarlet colour, about three and one-third times as heavy as water. It has no taste. This same sulphuret may be formed also by pouring a solution of hydrosulphuric acid (sulphuretted hydrogen) into a solution of arsenious acid in hydrochloric (muriatic) acid. It falls in the form of a powder of a fine yellow colour. In this state the sulphuret is usually called orpiment.

Found native.

2. Sulphuret of arsenic occurs native both in the form of realgar and of orpiment. Native orpiment however is not in powder, but composed of thin plates which possess some degree of flexibility.

Metallic arsenic not used in medicine.

XII. Arsenic, in the metallic state, has not been applied to any medical use; but the acids which this metal furnishes are very powerful articles of the materia medica.

SECTION VI.

OF CHROMIUM.*

Chromium; how obtained.

I. Chromium may be obtained by the following process: Take two parts of the mineral called chromate of iron, which consists of an acid of chromium combined with an oxide of iron, and expose it, mixed with one part of nitrate of potash (nitre), to the action of a strong heat. By this means, part of the mineral will be decomposed. Digest the mass thus altered in water, until every thing soluble is taken up. Separate this solution and set it aside; it contains nothing but chromic acid. Treat the residue, left after the action of the water, with hydrochloric (muriatic) acid, which will dissolve off the oxide of iron, which had been previously combined with the separated chromic acid. What remains now of the mass is nothing but the undecomposed chromate. By repeating the treatment just detailed a number of times, the mineral is at last totally decomposed. This being effected, mix all the aqueous solutions of the chromic acid together, and saturate the whole by means of nitric acid (aqua fortis). This latter acid combines only with the chromic acid, without uniting to impurities, and may be made to crystallize in this state of combination. Separate the crystals of the combined acids, dissolve them in water, and mix the solution with a solution of nitrate of mercury, a

* From χρῶμα colour; because it has the property of giving colour to other bodies in a remarkable degree.

compound formed of nitric acid and oxide of mercury. The chromic acid immediately separates the nitric acid of the nitrate, combines itself with the oxide of mercury, and in this state precipitates in the form of chromate of mercury. Expose the chromate of mercury, after being well washed, to a strong heat in a stone-ware retort. The mercury is thereby volatilized, and nothing remains but pure chromic acid. Expose the chromic acid mixed with charcoal to a strong heat in a porcelain furnace. The charcoal combines with the oxygen of the acid, flying off in the form of carbonic acid; while the pure chromium remains behind.

How found in nature.

II. Chromium in its pure state has never been found native; but acidified and combined with oxide of lead it occurs in Siberia, under the name of the red lead ore of Siberia. The chromate of iron has been found in France, and abundantly near Baltimore in the United States.

Discovery.

III. In 1797 Vauquelin ascertained the true nature of the red lead ore of Siberia, by discovering that it contained a metallic body previously unknown. To this metallic body, he gave the name of chromium.

Properties.

IV. Chromium is a brittle metal, of a white colour, intermediate between that of tin and steel. It is capable of being polished. It is not altered when exposed to air, but becomes oxidized when subjected to heat. Acids act upon it with great difficulty.

Spec. grav. 5·90.

V. It is somewhat less than six times as heavy as water. It requires a very high temperature to bring it into a state of fusion.

Forms three compounds with oxygen; one of which is an acid.

VI. Chromium combines with oxygen in three proportions, and forms compounds which are called protoxide of chromium, deutoxide of chromium, and chromic acid. The last named compound will be described under the head of acids.

1. Protoxide or green oxide.

1. Protoxide of chromium may be prepared by exposing chromic acid to heat in close vessels. Oxygen gas is driven off and the acid is reduced to the state of this oxide. It has a green colour. It is very soluble in acids, but is not capable of forming salts by combining with them. Its exact composition has not been determined.

2. Deutoxide or brown oxide.

2. Deutoxide of chromium may be prepared by dissolving the protoxide in nitric acid (aqua fortis), evaporating the solution to dryness, and exposing the dry mass to heat until it cease to emit nitrous fumes. It is a brown brilliant powder, scarcely soluble in potash or soda. It is totally insoluble in acids, and consequently incapable of forming any salt.

SECTION VII.

OF MOLYBDENUM.*

Molybdenum; how obtained.

I. MOLYBDENUM may be obtained by the following process: Roast the mineral called molybdena, which is a sulphuret of the metal under consideration, slowly and repeatedly at a moderate red heat, until it is reduced to the state of a fine powder. By this treatment the sulphur is driven off, and the metal is oxidized. In order to separate any impurity, dissolve the powder in pure ammonia, filter the solution thus formed and evaporate it to dryness. The ammonia dissolves the oxide alone, leaving the impurities; and when the solution is evaporated to dryness, the ammonia is is driven off, and nothing remains but pure oxide of molybdenum. Mix the pure oxide thus obtained with some charcoal powder, and expose it to a violent heat; its oxygen combines with the charcoal forming carbonic acid, while the pure molybdenum remains behind.

History of discovery.

II. Molybdena, the mineral from which molybdenum is generally obtained, was first analyzed by Scheele, who ascertained it to be composed of sulphur and a white powder which possessed acid properties. Bergman suspected that the acid powder discovered by Scheele was a peculiar acid, containing a metal before that time altogether unknown. This suspicion was soon after confirmed by Hjelm, who had undertaken the analysis of the powder at the request of Bergman.

Minerals of molybdenum, where found.

III. Besides in molybdena (sulphuret of molybdenum) molybdenum has been discovered in Carinthia, in another mineral, called molybdate of lead (a compound of an acid of molybdenum and oxide of lead).

Both these minerals have been found in the United States. The sulphuret occurs most abundantly in Maine; the molybdate of lead has been found in the Perkiomen lead mine, near Philadelphia, and the Northampton lead mine, Massachusetts.†

Properties.

IV. Molybdenum is a brittle metal of a silvery white colour, possessing frequently a shade of yellow.

Hjelm 7·400. Bucholz 8·611.

V. It is between seven and a half and eight and a half times as heavy as water. It is extremely infusible; no heat

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* From μολυβδαινα plumbago or black lead; because the mineral from which molybdenum is obtained, was formerly considered a species of plumbago.

† See Cleaveland's Mineralogy.

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to which it has been hitherto exposed has been sufficient to melt it into a solid button.

Forms three compounds with oxygen; two of which are acids.

VI. Molybdenum combines with oxygen in three proportions, and forms oxide of molybdenum, molybdous acid, and molybdic acid. The two last named compounds, having acid properties, will be deferred for description under the head of acids.

Oxide of molybdenum; how obtained.

1. Oxide of molybdenum may be obtained by exposing to a white heat, in a crucible, the compound formed of molybdic acid and ammonia, mixed with some charcoal. The molybdic acid of the compound, by this measure, is partly deoxidized, and reduced to the state of this oxide.

Properties.

2. It has a copper brown colour, and a crystallized appearance. It does not possess the property of forming salts with acids.

Molybdenum forms a sulphuret;

VII. Molybdenum combines with sulphur, and forms sulphuret of molybdenum. It is exactly similar to the native sulphuret called molybdena.

how obtained.

1. Sulphuret of molybdenum may be obtained by distilling together one part of molybdic acid and five parts of sulphur; the oxygen of the acid is separated, while the metal unites with the sulphur.

Properties.

2. This sulphuret has a bluish colour, very much like that of lead. In texture it is composed of scaly particles, which adhere slightly to each other.

VIII. Molybdenum forms no other compounds with the substances already described of sufficient importance to be noticed.

SECTION VIII.

OF TUNGSTEN.

Syn. *Wolframium—Scheelium.*

Tungsten; how obtained.

I. Tungsten may be obtained by the following process: Digest one part of the mineral called tungsten (a compound of an acid, whose base is metallic tungsten, and lime) reduced to powder, in three parts of nitric acid (aqua fortis) until it acquire a yellow colour. The nitric acid decomposes part of the mineral, combines with its lime, and sets free a portion of the acid of tungsten. Treat the residue with ammonia, by which means the free tungstic acid is taken up. Put the ammoniacal solution aside. By repeating the treatment, as already described, for a number of times, the mineral may at last be totally decomposed. Now mix

all the ammoniacal solutions of the tungstic acid together, and add nitric acid as long as any precipitate may appear. The nitric acid thus added combines with the ammonia; and the tungstic acid set free, being insoluble, causes the precipitate above alluded to. Separate the precipitate, and let it be well washed and dried. Then expose it, mixed with charcoal, to a violent heat, in a covered crucible. The charcoal robs the acid of its oxygen, so that nothing remains but pure tungsten. Chap. III.

II. In 1781, Scheele analyzed the mineral called tungsten, and resolved it into lime, and a peculiar acid which he called tungstic acid. Bergman suspected the base of this acid to be metallic, and his suspicion was afterwards verified by the Messrs. D'Elhuyarts. These chemists found the tungstic acid of Scheele in another mineral called wolfram;* and they succeeded in decomposing it, by mixing it with charcoal, and exposing it to a very intense heat. Discovery.

III. Tungsten is a brittle metal of a greyish white colour like that of steel. It possesses considerable brilliancy. It is one of the hardest metallic bodies. Properties.

IV. It is one of the heaviest of the metals; being very nearly seventeen and a half times as heavy as water. It requires a very high degree of heat to bring it into a state of fusion; not less than 170° of Wedgewood. When heated in the open air, it becomes oxidized. Spec. grav. 17·4.

V. Tungsten combines with oxygen in two proportions, and forms compounds called oxide of tungsten and tungstic acid. The latter compound having acid properties, its description will be deferred until the class of acids come to be treated of. Forms two compounds with oxygen; one of which is an acid.

1. Oxide of tungsten may be formed by passing a current of hydrosulphuric acid (sulphuretted hydrogen) through a quantity of tungstic acid, heated to redness in a glass tube. The hydrogen of the former abstracts part of the oxygen from the latter, which is thereby reduced to the state of this oxide. Oxide of tungsten; how obtained.

2. Oxide of tungsten has a flea brown colour. When heated in the open air, it takes fire and is converted into tungstic acid. It is not capable of forming salts with acids. Properties.

VI. Tungsten combines with sulphur, and forms sulphuret of tungsten. This sulphuret may be obtained by exposing a mixture of one part of tungstic acid and four parts of sulphuret of mercury, in a retort, covered with charcoal, to Tungsten forms a sulphuret.

* Wolfram consists of tungstic acid, combined with manganese and iron.

a violent heat for half an hour. It is in the form of a greyish black powder.

VII. Tungsten forms no alloys with the metals already described.

SECTION IX.

OF COLUMBIUM.

Tantalum of Ekeberg.

Columbium; how obtained: I. COLUMBIUM may be obtained by the following process: Fuse together one part of the mineral called tantalite,* five parts of salt of tartar, and two parts of borax, in a platinum crucible. This fusion is performed in order to make the mineral more soluble in acids. Soften the fused mass with water, and then digest in hydrochloric (muriatic) acid. This acid dissolves off the oxides of iron and of manganese, leaving the oxide of columbium untouched. Separate the oxide of columbium from the dissolved oxides, and let it be washed and dried. Then expose it to a violent heat in a charcoal crucible. The charcoal combines with its oxygen, and reduces it to the metallic state.

in what minerals found and where. II. Columbium has heretofore been found in two minerals only; the tantalite of Ekeberg, and the columbite of Hatchett. Ekeberg's specimen was found in Sweden; Hatchett's came from America.

History of discovery. III. This metal was first discovered, in 1801, by Hatchett, as a constituent in a mineral belonging to the British museum, which had been sent by Mr. Winthrop of Massachusetts to Sir Hans Sloane. Hatchett gave it the name of columbium. Soon after this discovery, Ekeberg detected a new metal in a mineral found in Sweden, to which he gave the name of tantalum. In 1809, Dr. Wollaston proved that the columbium of Hatchett, and the tantalum of Ekeberg, were the same metal.

Properties. IV. Columbium is a dark grey metal, showing the metallic lustre when rubbed against a fine grindstone. It is one of the most infusible metals known, and so hard that its grains are capable of scratching glass. It is also very brittle, and may be reduced to powder in a mortar. It is extremely insoluble; not being acted upon by hydrochloric

* Tantalite is composed of oxide of columbium combined with oxide of iron and of manganese.

(muriatic) acid, nitric acid, or a mixture of these acids usually called aqua regia, although digested upon it for several days. Chap. III.

V. Columbium is somewhat more than five and a half times as heavy as water. Spec. grav. 5·61.

VI. When heated to redness, it burns feebly without any flame; but the combustion ceases the moment it is withdrawn from the fire. How it burns.

VII. Columbium combines with oxygen in one proportion only; and forms a compound called columbic acid. This compound, having acid properties, its consideration will be deferred until the class of acids come to be treated of. Forms one compound with oxygen; which is an acid.

VIII. Columbium forms no important alloys.

SECTION X.

OF SELENIUM.*

I. This substance was discovered about the beginning of the year 1818, by the celebrated Swedish chemist Berzelius, in the iron pyrites of the mine of Fahlum in Sweden. It had been mistaken for the metallic substance called tellurium, which will be described hereafter. Berzelius has since found that it constitutes one-fourth of a mineral previously supposed to be an ore of tellurium, in which it is associated with silver and copper. Selenium, discovered by Berzelius.

II. Selenium is considered by Berzelius to be a metal, although having many analogies to sulphur. It has a brilliant metallic lustre, with a tinge of red. When cooled rapidly it exhibits the vitreous fracture; but, after slow cooling, its fracture is granulated. It is about four and a half times as heavy as water. It has a certain, but scarcely perceptible, transparency. It softens at the heat of boiling water, and in a higher heat, melts. When heated sufficiently, it is converted into a yellow vapour like sulphur. It may be sublimed in large vessels, and deposites flowers of the colour of cinnabar. It acquires a certain degree of consistency while cooling, in which state it may be moulded in the fingers, or drawn into very fine threads. In a candle it burns with an azure-blue flame, and emits an Its properties. Spec. grav. 4·6.

* From Σελήνη the moon, on account of its analogy to the metal called tellurium, which is derived from tellus, the earth.

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odour resembling that of horse-radish, and so powerful that one-fiftieth of a grain of it, thus treated, is sufficient to scent a large room.

It forms an acid with oxygen or hydrogen indifferently.

III. Selenium combines with oxygen in one proportion, and forms an acid. It is therefore an acidifiable combustible. Selenic acid will be described hereafter under the head of acids. It combines also with hydrogen, forming what is called selenuretted hydrogen. This gas has considerable resemblance to hydrosulphuric acid (sulphuretted hydrogen), and forms compounds analogous to salts, by combining with salifiable bases. It will be described hereafter under the name of hydroselenic acid.*

CLASS III.

INTERMEDIATE COMBUSTIBLES.

Intermediate combustibles defined,

This class contains those combustibles, whose compounds with oxygen are capable of performing the part of acids, or of salifiable bases, under different circumstances, in the formation of neutral salts.

and enumerated.

There are only two combustibles belonging to this class; namely, antimony and tellurium. These substances will form the subjects of the two following sections.

SECTION I.

OF ANTIMONY.

Antimony, how obtained.

I. Antimony may be obtained by the following process: Project by degrees 100 parts of sulphuret of antimony (crude antimony), upon 32 parts of iron filings, previously heated to redness in a crucible. When the whole is in a state of fusion, add by degrees 20 parts of nitrate of potash (nitre); keep it in this state for a few minutes, and then pour it into an iron melting cone, previously heated and greased. The metal, tolerably pure, will be found at the bottom of the cone.

How found.

II. Pure antimony very seldom occurs native. It occurs most abundantly mineralized with sulphur. In its pure state it has been found at Harwington, in Connecticut. In the form of sulphuret it occurs in several parts of the United States.†

* For a further account of selenium, see Thomson's Annals, vol. xi. 1818.
† See Cleaveland's Mineralogy.

III. Pure metallic antimony was not known to the ancients; and although they were acquainted with the sulphuret of antimony, it does not appear that they supposed it to be of a metallic nature. Who first obtained it in the pure state is not at present known; but the process for procuring it was first described by Basil Valentine, in his writings on antimony, towards the end of the fifteenth century. Chap. III. Not known pure to the ancients.

IV. Antimony is a brittle metal of a greyish white colour, and laminated texture. It possesses a good deal of brilliancy. Its hardness is about equal to that of gold. It communicates to the fingers, when rubbed upon it, a peculiar taste and smell. When exposed to the open air, it undergoes no change except the loss of lustre. Properties.

V. Antimony is six and nearly three-fourth times as heavy as an equal bulk of water. It melts when heated to redness; if the heat be increased beyond that point, it evaporates. Spec. grav. 6·712.

VI. Antimony is capable of combustion. When exposed to a white heat, and then suddenly agitated, it takes on that process. The product of the combustion is an acid called antimonious acid.

VII. Antimony combines with oxygen in three proportions, and forms compounds which are called oxide of antimony, antimonious acid, and antimonic acid. The two latter compounds having acid properties, their description will be deferred until the class of acids come under consideration. The oxide of antimony will be considered in this place. Forms three compounds with oxygen; two of which are acids.

OXIDE OF ANTIMONY.

Precipitated Calx of Antimony of the Dublin College.

1. Oxide of antimony may be obtained by diluting with water a solution of antimony in hydrochloric (muriatic) acid. A precipitate appears, which consists of the oxide of antimony, combined with a little hydrochloric acid. To separate the acid, wash the precipitate, and boil it for some time in a solution of salt of tartar; wash it again and dry it on a filter. The precipitate is now pure oxide of antimony. Oxide of antimony; how obtained.

2. Oxide of antimony is of a dirty white colour, and destitute of lustre. It is extremely fusible. It has the property of forming salts by combining with acids. Properties.

3. Oxide of antimony was formerly used in medicine. At present, however, it is not employed except in combination with sulphuret of antimony, with which it unites in several proportions. These compounds will be described presently. Medical uses.

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VIII. Antimony combines with chlorine, and forms chloride of antimony.

Antimony forms a chloride; how obtained.

CHLORIDE OF ANTIMONY.

Muriate of Antimony of the Ed. College; formerly called *Butter of Antimony.*

1. This chloride may be obtained by distilling a mixture of two parts of corrosive sublimate (a chloride of mercury) and one part of antimony. It is formed also by the combustion of antimony in chlorine gas. When introduced into this gas, the metal catches fire, and the product is the chloride under consideration.

Properties.

2. Chloride of antimony is a fatty looking substance, of a greyish white colour; very deliquescent and very volatile. When heated moderately it melts. When mixed with water, this liquid is decomposed; its hydrogen combines with the chlorine, forming hydrochloric (muriatic) acid, while its oxygen forms antimonious acid with the antimony.

Composition.

3. Chloride of antimony is composed of

Antimony	45
Chlorine	36
	81

Medical uses.

4. Chloride of antimony constitutes one of the most powerful caustics known. Being however in a liquid form it is difficult to limit its operation. At present it is never used as an escharotic.

Iodide of antimony.

IX. Antimony combines with iodine, and forms iodide of antimony. It is very readily obtained by fusing its constituents together. It has a dark red colour. When digested in water, it is converted into hydriodic acid and oxide of antimony; that liquid being at the same time decomposed.

Phosphuret.

X. Antimony combines with phosphorus and forms phosphuret of antimony. It may be prepared by dropping phosphorus into melted antimony. It is a brittle substance, of a white colour and laminated texture.

XI. Antimony combines with sulphur, and forms sulphuret of antimony.

Sulphuret.

SULPHURET OF ANTIMONY.

Crude Antimony.

1. Sulphuret of antimony may be formed by fusing together its component parts in a crucible.

2. This sulphuret occurs native, and constitutes a very abundant ore of antimony.

Properties.

3. It has a light leaden grey colour and the metallic lustre. Its texture is foliated or radiated. It is much more

fusible than pure antimony. It is about four and one-third times as heavy as water.

4. Sulphuret of antimony combines in several proportions with the oxide of antimony. This combination in the general way is formed by adding the sulphuret to the oxide while in a state of fusion. It may be formed also by melting in a crucible, the oxide of antimony with different proportions of sulphur: part of the antimony is thereby revived and unites to the sulphur forming a sulphuret; and this sulphuret combines with the remaining undecomposed oxide. The acids of antimony may be employed, for fusion with sulphur as well as the oxide, in the formation of these compounds; as the former are always reduced to the state of the latter during the process. Combines with oxide of antimony in several proportions.

When the sulphuret of antimony is united to the oxide in the proportion of one part of the former with eight of the latter, and the compound fused by a sudden heat, it constitutes the preparation called glass of antimony. In one proportion

GLASS OF ANTIMONY.

Vitrified Oxide of Antimony with Sulphur of the Ed. College.

[1.] Glass of antimony is prepared by the apothecaries, by exposing sulphuret of antimony in powder, to a gentle heat, for a considerable time, in an open vessel. This exposure to heat has the effect of driving off the sulphur from one part of the antimony, which is then converted into oxide. Part of the sulphuret, being in this way oxidized, the whole is melted in a crucible, and kept at an intense heat until it assume the appearance of glass. It is a semitransparent substance of a fine red colour. forms glass of antimony.

[2.] Glass of antimony was formerly used in medicine as an emetic; but its operation is so very irregular and uncertain, that it has gone out of use. When melted with one-eighth of its weight of yellow wax, it forms the preparation called *cerated glass of antimony*. The cerated glass is both emetic and cathartic, but more certainly the latter. At present it is not much employed; and most probably for the same reason that the use of the glass has been discontinued. Medical uses.

Sulphuret of antimony, combined with oxide of antimony in the proportion of one part of the former with four of the latter, constitutes the preparation called crocus of antimony. In another proportion,

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CROCUS OF ANTIMONY.

Also called *Crocus Metallorum.—Oxide of Antimony, with Sulphur, by Nitrate of Potash*, of the Ed. College.

Crocus of antimony.

[1.] Crocus of antimony may be prepared in the following manner. Expose a mixture of equal parts of sulphuret of antimony and nitrate of potash (nitre) each separately pulverized, to a red heat in a covered crucible. A red matter is produced, which must be separated from a whitish crust which is also formed, and afterwards reduced to powder and washed, until the water employed comes off tasteless. This red matter is the crocus of antimony.

Medical uses.

[2.] Crocus of antimony agrees in medical properties with the glass; but like the latter preparation, it sometimes acts mildly, at other times most violently. It has accordingly gone entirely out of use.

Composition of the sulphuret.

5. Sulphuret of antimony forms no other important compounds than the two just described. It is composed of

Antimony	45
Sulphur	16
	61

Medical uses of the sulphuret.

6. When reduced to the state of impalpable powder, sulphuret of antimony is sometimes employed in medicine. In general its operation is that of a diaphoretic; but occasionally, especially if it meet with acid in the stomach, it is violently emetic and cathartic. It is a powerful remedy in glandular obstructions, and in obstinate cutaneous eruptions. The dose is from ten to thirty grains.

XII. Antimony forms no important alloys with the metals already described.

Pure antimony not medicinal.

XIII. Antimony in the metallic state appears to have very little or no medical properties.

SECTION II.

OF TELLURIUM.

Tellurium: how obtained.

I. Tellurium may be obtained by the following process: Dissolve the ore in which tellurium is alloyed with gold and iron, in a mixture of hydrochloric (muriatic) and nitric acids, commonly called aqua regia; and precipitate the gold and iron by adding potash in excess. Separate the precipitate, and then add to the solution, hydrochoric (muriatic) acid, just sufficient to saturate the excess of potash: a precipitate appears, which consists of the oxide of tellurium.

The metal may be obtained from the oxide, by exposing it, formed into a paste with linseed oil, to heat in a retort. Brilliant metallic drops make their appearance in the upper part of the retort; these drops consist of tellurium in a state of purity.

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II. The ores from which tellurium is extracted, have heretofore been found only in Transylvania.

Where found.

III. In 1782 Muller was led to believe that the white gold ore (one of the ores of tellurium) contained a new metal, different from all others at that time known. This conclusion was completely confirmed in 1798 by Klaproth.

Account of discovery.

IV. Tellurium is a bluish white metal of a laminated texture, possessing considerable brilliancy. It is very brittle, and may be easily reduced to powder. Next to mercury and arsenic, it is the most volatile of all the metals.

Properties.

V. Tellurium is somewhat more than six times as heavy as water.

Spec. grav. 6·115.

VI. When tellurium is exposed to the action of the blowpipe, upon burning charcoal, it takes fire and burns with a lively blue flame, edged with green.

Its combustion described.

VII. Tellurium combines with oxygen in one proportion only, and forms a compound possessing acid properties. Dr. Thomson calls it telluric acid. But as it enters, as a constituent into neutral salts, sometimes as an acid and sometimes as a salifiable base; it would perhaps be better to call it either telluric acid or oxide of tellurium, according to the part which it may perform in the constitution of any particular salt. It will be described in this place as a base.

Forms one compound with oxygen, with acid properties.

It will be described here as

1. Oxide of tellurium may be formed by dissolving the metal in aqua regia, and diluting the solution with a large quantity of water: a precipitate falls which consists of this oxide.

oxide of tellurium: how obtained.

2. Oxide of tellurium has a white colour. When exposed to heat, it melts readily into a straw-coloured mass; after fusion if the heat be increased, it is volatilized. When made into a paste with oil or charcoal powder, it is deoxidized with a kind of explosion.

Properties.

3. It is composed of

Composition.

Tellurium	32
Oxygen	8
	40

This oxide, in consequence of its acting the part of an acid in some salts, will be noticed hereafter in the enumeration of the acids.

VIII. Tellurium combines with chlorine and forms chloride of tellurium. It is easily formed by introducing the metal into chlorine gas; it catches fire spontaneously, and the product of the combustion is this chloride.

Chloride of tellurium.

Properties. 1. Chloride of tellurium is a white and semitransparent substance. When heated it is converted into vapour. Water decomposes it, and precipitates the tellurium in the state of oxide combined with water.

Composition. 2. This chloride is composed of

Tellurium	32
Chlorine	29·5*
	61·5

Iodide. IX. Tellurium combines with iodine, when brought in contact with it. The iodide thus obtained, forms a dark purple-red solution in water.

Tellurium forms an acid compound with hydrogen. X. Tellurium combines with hydrogen and forms a gaseous compound called telluretted hydrogen. This gas possesses the more essential properties of an acid, and will be described hereafter under the name of hydrotelluric acid.

Sulphuret. XI. Tellurium combines by fusion with sulphur; and the sulphuret formed has a leaden colour.

XII. Tellurium forms no important alloys with the metals already described.

CLASS IV.

BASIFIABLE COMBUSTIBLES.

Basifiable combustibles defined. Basifiable combustibles have already been defined, to be those combustibles which form the bases of neutral salts, but in no instance acids, by combining with oxygen. These combustibles will be arranged in three sub-classes, as has been already mentioned.

SUB-CLASS I.

ALKALIFIABLE COMBUSTIBLES.

First sub-class of them defined, and This sub-class includes those basifiable combustibles, which form salifiable bases, possessing alkaline properties, by combining with oxygen. All the salifiable bases formed from these combustibles change vegetable blues to green, with more or less energy. These combustibles are the following: namely,

enumerated. 1. Potassium; 2. Sodium; 3. Lithium; 4. Calcium; 5. Barium; 6. Strontium; 7. Magnesium.

These substances will form the subjects of the seven following sections.

SECTION I.

OF POTASSIUM.

Potassium: how obtained. I. Potassium may be obtained by the following process: Bend a gun barrel in such a form as that its central portion

will form a curve below the level of its extremities. Fill this central portion with a quantity of turnings of iron quite clean; and then fix the gun barrel in a furnace surrounded with clay to preserve it from fusion. Place one extremity of the barrel a little higher than the other. Put into the upper extremity a quantity of potash, made as pure and dry as possible; and then adapt to it a curved tube, with its lower extremity plunged into a vessel of mercury. Heat that part of the gun-barrel which contains the iron turnings, to whiteness; and at the moment that this is accomplished, lute a short copper tube to the lower extremity of the gun-barrel, and keep it as cool as possible. Things being thus arranged, apply a sufficient heat to the upper extremity of the gun-barrel, to convert the potash, contained in it, into vapour. The potash thus vaporized passes through the iron turnings, and becomes decomposed, and the substance called potassium condenses in the copper tube. As soon as all the potash employed has been converted into vapour, which will be known by there ceasing to be any farther gaseous products, the heat is to be discontinued. The apparatus, after having its ends closed with luting, is then taken from the furnace and cooled as soon as possible. The substance called potassium will be found in the copper tube. To preserve it pure it must be kept under naphtha.*

Explanation of the process.

II. Potash is composed of the substance under description and oxygen. The explanation of the above process is therefore this: the potash in vapour, by coming in contact with the iron turnings raised to a white heat, is instantly decomposed; its oxygen combines with the iron, while the potassium liberated from combination passes on and condenses in the copper tube.

Discovery.

III. The important discovery of the compound nature of potash was made in 1807, by Sir H. Davy, by the agency of galvanic electricity. The process just described is an outline of that invented by Gay-Lussac and Thenard.

Properties.

IV. Potassium is a white metal, possessing the metallic lustre as perfectly as mercury or silver. At the temperature of 50° it is soft and malleable; at 136½° it is perfectly liquid; while at 32° it is hard and brittle. When thrown into water it decomposes that liquid; the hydrogen evolved, carrying with it small particles of the metal, catches fire, and causes the whole of the potassium to burn with a kind of explosion.

Spec. grav. 0·865.

V. Potassium is lighter than water, being only between eight and nine-tenths as heavy as that liquid.

Forms with oxygen, potash, and

VI. Potassium combines in two proportions with oxygen, and forms compounds called potash and peroxide of potas-

* Naphtha is a fine thin colourless oil, which comes from Persia.

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sium. The former is formed by the combustion of potassium in atmospheric air. It will receive a separate consideration under the head of alkaline salifiable bases; the latter will be noticed in this place.

peroxide of potassium: how obtained. 1. Peroxide of potassium is formed by heating potassium in pure oxygen gas. A vivid combustion takes place, and the potassium combines with a larger dose of oxygen, than by combustion in the open air.

Discovery. 2. Peroxide of potassium was discovered in 1810, by Gay-Lussac and Thenard.

Properties. 3. It is a solid body, of a yellow colour. When thrown into water, it parts with so much oxygen as to convert it into potash. When brought into contact with sulphur, phosphorus, or carbon and the temperature raised, combustion takes place; these bodies become acidified, and thus changed, unite to the peroxide now reduced to the state of potash. Under similar circumstances, it converts sulphurous acid and protoxide of azote into sulphuric acid and nitric acid respectively.

Chloride of potassium: VII. Potassium combines with chlorine, and forms chloride of potassium.

CHLORIDE OF POTASSIUM.

Usually called *Muriate of Potash.—Febrifuge or Digestive Salt* of Sylvius. *Regenerated Sea Salt* of Boerhaave.

how obtained. 1. Chloride of potassium may be obtained by saturating potash with hydrochloric (muriatic) acid, and exposing the compound formed to a red heat. The chlorine of the acid* combines with the potassium of the potash, while the hydrogen of the former and oxygen of the latter unite and form water. The exposure to a red heat of the compound has the effect of driving off the water in a state of vapour; so that nothing then remains but chloride of potassium.

Another method. 2. Another method for obtaining this chloride is to heat potash in chlorine. The chlorine combines with the potassium of the potash, while the oxygen of the latter is disengaged. It is also formed when potassium is burnt in chlorine gas; the combustion is attended with a brilliant red flame.

Properties. 3. Chloride of potassium has a white colour, and a taste resembling that of common salt, but more inclined to bitter. It is not altered by exposure to the atmosphere.

Composition. 4. It is composed of

Potassium	40
Chlorine	36
	76

* The reader is presumed to be acquainted with the constituents of hydrochloric acid; they having been mentioned under the head of hydrogen, p. 20.

5. Chloride of potassium was formerly used in medicine as a sudorific; but at present it has gone entirely out of use.

Iodide of potassium.

VIII. Potassium combines with iodine and forms iodide of potassium. It may be formed by causing the vapour of iodine to come in contact with potassium; the metal takes fire and burns with a violet coloured flame, and this iodide is formed as the product of the combustion. It is in the form of crystals possessing a pearly lustre. It dissolves readily in water. Its exact composition has not been ascertained.

Hydruret of potassium.

IX. Potassium combines with hydrogen and forms the compound called hydruret of potassium. It may be obtained by heating the metal in hydrogen gas. It is a grey substance destitute of metallic lustre. It is infusible in any heat to which it has as yet been exposed. It does not burn spontaneously either in common air or oxygen gas. It decomposes water, and is converted into potash, while its hydrogen, together with that furnished by the water, is evolved. It was discovered by Gay-Lussac and Thenard.

Properties.

Potassium burns when heated in protoxide of azote, and also in carbonic oxide.

X. Potassium exerts no action upon azote; but when heated in the protoxide of azote (nitrous oxide), it takes fire and combines with oxygen in the proportion to form peroxide of potassium.

XI. Potassium is not known to have any action upon carbon; but when heated in carbonic oxide, it catches fire, and is converted into potash by combining with the oxygen of this gas, while its carbon is deposited.

Phosphuret of potassium.

XII. Potassium combines with phosphorus and forms phosphuret of potassium. It is easily prepared by heating its constituents in contact with each other. Their combination is attended by the emission of a weak light. It is of a chocolate colour. It burns readily in the open air; and when thrown into water, a kind of detonation is produced in consequence of the rapid evolution of hydroguret of phosphorus (phosphuretted hydrogen). It is composed of

Composition.

Potassium	40
Phosphorus	12
	52

Sulphuret.

XIII. Potassium combines with sulphur and forms sulphuret of potassium. It may be obtained by heating together its constituents; an intense chemical action occurs, attended by all the phenomena of a violent combustion, and the product is this sulphuret. It is of a dark grey colour. When thrown upon water, it acts upon that liquid with great energy, and hydrosulphuric acid (sulphuretted hydrogen) is evolved. Although a product of combustion, it is

Properties.

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nevertheless capable of undergoing that process, by which it is converted into sulphate of potash; its ingredients first uniting with oxygen and afterwards combining with each other. Sulphuret of potassium is composed of

Composition.

Potassium	40
Sulphur	16
	56

XIV. Potassium forms no important alloys with the metals already described.

SECTION II.

OF SODIUM.

Sodium: how obtained.

I. Sodium may be obtained from pure soda by a process precisely similar to that just described for obtaining potassium. It may be obtained also by exposing a mixture of dry common salt and potassium to heat in a close vessel. The salt is decomposed and sodium appears. The explanation of the latter process for obtaining sodium is this. Common salt is a compound of chlorine and sodium. When this compound is heated in mixture with potassium, its chlorine combines with the potassium, forming chloride of potassium; while the sodium liberated from combination appears in its pure state.

Discovery.

II. Sodium was discovered in 1808 by Sir H. Davy as a constituent in soda, which substance this chemist first decomposed by the agency of galvanic electricity.

Properties.

III. Sodium is a metal of a white colour, intermediate between that of silver and lead. At the common temperature of the atmosphere, it is soft and malleable. Its fusing point is at the temperature of 194°.

Spec. grav. 0·972.

IV. It is very nearly as heavy as water.

Forms soda by combustion in open air; and

V. Sodium burns in the open air when sufficiently heated, and combines with oxygen. The product of the combustion is soda; soda therefore is an oxide of sodium. Soda is also formed when sodium is exposed to the open air; the surface of the metal being converted into soda, by the decomposition of the moisture of the atmosphere. When sodium is thrown into water, this liquid is decomposed, hydrogen is evolved, and it is converted into soda. Soda will receive a separate consideration under the head of alkaline salifiable bases. Besides soda, sodium forms another oxide by combining with a larger dose of oxygen than exists in soda; this compound is called peroxide of sodium, and will be noticed in this place.

Chap. III.

1. Peroxide of sodium may be formed by heating sodium in oxygen gas; the metal takes fire and burns with great splendour. The product of the combustion is this peroxide. It is of a dirty greenish yellow colour. When thrown into water, it gives off so much of its oxygen as to be reduced to the state of soda. It was discovered by Gay-Lussac and Thenard. It is composed of

Peroxide of sodium by combustion in oxygen gas.

Composition.

Sodium	48
Oxygen	24
	72

VI. Sodium combines with chlorine and forms chloride of sodium.

CHLORIDE OF SODIUM.

Usually called *Muriate of Soda.*—Common names, *Common Salt.—Sea Salt.*

1. Chloride of sodium may be obtained by saturating common soda (carbonate of soda) with hydrochloric (muriatic) acid. Its formation in this case takes place in consequence of a double decomposition. The carbonic acid of the carbonate is liberated and flies off in the form of gas; the chlorine of the hydrochloric acid combines with the sodium of the soda; while the hydrogen of the former uniting with the oxygen of the latter, forms water. It may be obtained however free from water by burning sodium in chlorine gas. The combustion is vivid, and attended by the emission of bright red sparks. The dry chloride also may be obtained by passing a current of chlorine gas over soda previously heated to redness: the chlorine combines with the sodium of the soda, while its oxygen is set free.

Chloride of sodium: how obtained.

2. Chloride of sodium has been known from the earliest ages; but it has only been by very gradual steps that its true nature has been ascertained. Glauber knew that hydrochloric (muriatic) acid could be obtained from it, and Stahl asserted that its base was alkaline. Duhamel ascertained that the base which appeared upon its decomposition was soda, and distinguished it from potash. From these facts, common salt was supposed to be proved to consist of hydrochloric (muriatic) acid and soda; and it had never been suspected that these alleged constituents did not exist in it, but were in fact the results of new combinations, occurring during its decomposition, before Sir H. Davy made the remarkable discovery, that oxymuriatic acid (chlorine) as yet was an undecompounded substance; which lead the way to the ascertaining of the true nature of the compound under consideration.

Researches into its chemical nature.

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Chloride of sodium occurs abundantly native.

3. The processes just given for obtaining chloride of sodium (common salt) are merely for the purpose of illustrating its composition. The chemist has no occasion to resort to them; as this chloride occurs abundantly native in all parts of the world. It occurs in masses forming the chief part of some mountains. It is found also in solution, in springs, and lakes, but particularly in the ocean. The principal salt mines are found in Poland, Hungary, England and Spain. That near Cracow in Poland has been worked ever since the year 1251. Salt springs are found in almost all parts of the world. Salt lakes are almost peculiar to Russia.

Its extraction from salt mines, and salt springs described.

4. Chloride of sodium (common salt) is obtained from its various sources by different kinds of management. It is extracted from salt mines in blocks. If sufficiently pure all that is necessary is to pound it for use; otherwise it must be purified by solution and crystallization. When it occurs in nature in solution, it is extracted by evaporation. If the water contain 15 per cent. of salt, it is generally exposed to artificial heat in a series of large shallow iron pans for evaporation. It deposites the principal impurities in the first pans; and by the time that it has arrived at the last pan in the series, the liquid is a saturated and tolerably pure solution of common salt. The salt precipitates, and is raked out and placed to drain on an inclined plane, at the edge of the last evaporating pan.

If a salt spring contain but a small portion of salt, it may cause too great expense in fuel to extract it by the method of artificial heat. In this case, it is brought to the requisite strength, which is considered to be that of containing 30 per cent. of salt, by means of an operation, called graduating. This consists in pumping up the brine to the height of nine or ten yards, and allowing it to fall upon a pile of faggots, upon which it is distributed by means of troughs. There is a reservoir below, to receive the brine as it falls. This management has the effect of exposing the brine to the air, minutely divided; whereby evaporation, the sole object of the process, is greatly increased. The brine is pumped up again and again, and allowed to fall over the faggots, until it has acquired the requisite concentration. It is then subjected to evaporation by artificial heat.

Sea-water furnishes a great deal of common salt.

A great deal of common salt is extracted from sea-water by evaporation. This water contains between two and three per cent. of common salt. After being first concentrated in large reservoirs, by evaporation in the sun, until it contain about 30 per cent. of salt, it is subjected to artificial evaporation.

5. Chloride of sodium (common salt) has the well known taste, which is distinguished by the epithet *salt*. It crystallizes in cubes. It dissolves in about 2·8 parts of cold water, and in about 2·7 parts of boiling water. When somewhat heated, it decrepitates; at a red heat it melts; and at a white heat it evaporates, without undergoing decomposition, in the form of a white smoke. When pure it is not affected by exposure to air; but if contaminated by chloride of magnesium (muriate of magnesia) it becomes deliquescent. Hence moistness in common salt is an indication of impurity. It is somewhat more than twice as heavy as water. Chap. III. Chloride of sodium described. Spec. grav. 2·125.

6. It is composed of

Sodium	24
Chlorine	36
	60

7. Chloride of sodium (common salt) is of immense utility to mankind. It would appear that man, as well as all phytivorous animals, have an instinctive relish for it as an article of food. It is unquestionably a strong and very grateful stimulus to the stomach, exciting that organ and promoting the process of digestion. It is one of the most powerful antiseptics known. By means of it the flesh of animals may be preserved, fit for food, for any length of time. This property of common salt makes it invaluable to mankind. Its general uses.

8. In medicine, chloride of sodium (common salt) is a very useful substance. In active hæmorrhagies of the lungs and stomach, it is one of the most efficacious and prompt remedies that can be used. In such cases, it may be given dry in the dose of a table spoonful. It is also well suited to some cases of worms in children. In solution it forms the salt bath, which is a very useful remedy in many diseases. It is particularly useful in the scrofulous habit; in chronic eruptions, and in short in all diseases, in which it is expedient to excite the vessels on the surface. Its uses as a medicine.

VII. Sodium does not act upon azote; but when heated in protoxide of azote (nitrous oxide), it combines with a maximum of oxygen and is converted into peroxide of sodium. Sodium burns in protoxide of azote,

VIII. Sodium has no action on carbon; but when heated in carbonic oxide gas, it takes fire and is converted into soda, carbon being deposited. and in carbonic oxide.

IX. When sodium and phosphorus are brought in contact, they combine with the emission of a feeble light. The result of the combination is phosphuret of sodium. It has the colour and appearance of lead. When exposed to the open air, or thrown into water, it combines with oxygen in Phosphuret of sodium.

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such a way as to be converted into phosphate of soda. It is composed of

Sodium	24
Phosphorus	12
	36

Sulphuret of sodium.

X. Sulphuret of sodium may be formed by bringing its constituents in contact. The union is attended by the characteristic phenomena of combustion; there being much heat and light emitted. It has a deep grey colour. When heated in the open air, it takes fire and is converted into sulphate of soda. It is composed of

Sodium	24
Sulphur	16
	40

XI. Sodium forms no important alloys with the metals already described.

SECTION III.

OF LITHIUM.

Lithium, the metallic radical of lithia, a new alkaline salifiable base.

I. LITHIUM is the name proposed to be given to the peculiar metallic substance, obtained by Sir H. Davy, upon the decomposition of lithia, a new alkaline salifiable base, discovered about the beginning of the year 1818, by Mr. Arfwedson, a young Swedish chemist, and a pupil of Berzelius.

II. Lithium has considerable resemblance to sodium. The only combination into which it is known to enter, is that with oxygen; whereby it forms lithia.* The alkaline nature of its oxide makes it proper to arrange it among the alkalifiable combustibles. Lithia will be noticed hereafter.

SECTION IV.

OF CALCIUM.

Calcium; how obtained.

I. CALCIUM may be obtained by exposing mercury to negative electricity in contact with pure lime. The lime is decomposed and its base calcium is found, in the state of an amalgam. The calcium may be separated from the mercury by distillation in the vapour of naphtha.

* See Annals of Philosophy, Vols. xi. and xii. (1818.)

II. While Sir H. Davy was pursuing his experiments upon lime, in order to decompose it, to which he was led by his previous discovery of the metallic radicals of potash and soda; he received a letter from Berzelius, in which the Swedish chemist communicated the information, that he had, in conjunction with Dr. Pontin, succeeded in decomposing this substance, and obtaining its radical in a state of combination with mercury.

Chap. III. Its discovery.

III. Calcium has been but very imperfectly examined. It is a solid metal of a white colour, resembling that of silver. It possesses considerable weight.

Properties.

IV. When calcium is heated in the open air, it burns brilliantly, and the product of the combustion is pure lime. Lime will be considered hereafter as an alkaline salifiable base. Calcium has been lately ascertained by Thenard to be capable of combining with more oxygen than exists in lime. This combination may be effected by adding lime in excess to superoxidized hydrochloric acid.* The oxygen existing in the acid becomes transferred to the lime and thereby forms a peroxide of calcium.†

Burns in the open air and forms lime.

Is capable of forming a peroxide.

V. Calcium combines in one proportion with chlorine, and forms chloride of calcium.

Calcium forms with chlorine, chloride of calcium.

CHLORIDE OF CALCIUM.

Usual chemical name—*Muriate of Lime.*

Old names—*Fixed Sal Ammoniac—Calcareous Marine Salt.*

1. Chloride of calcium may be obtained by saturating carbonate of lime (chalk) with hydrochloric (muriatic) acid. The carbonic acid is evolved; the oxygen of the lime combines with the hydrogen of the hydrochloric acid, so as to form water; while the calcium of the former and the chlorine of the latter unite to form the chloride. It may be obtained also by heating lime in chlorine gas. The lime becomes decomposed; its calcium combines with the chlorine, while its oxygen is set free.

This chloride; how obtained.

2. Chloride of calcium has a very bitter and pungent taste. It is very deliquescent and very soluble. It cannot be easily obtained in crystals. When exposed to a violent heat, a portion of hydrochloric (muriatic) acid is exhaled, which owes its formation to the decomposition of water. The chloride thus altered, has the property of shin-

Its properties.

* Thenard has very lately made the extraordinary discovery that hydrochloric (muriatic) acid, as well as many other acids, is capable of combining with a number of doses of oxygen. The peculiar method, which this chemist practised to effect these combinations, will be mentioned under the heads of the different acids respectively.

† Thomson's Annals. (Jan. 1819.)

ing in the dark, as Homberg first observed, and is usually called the phosphorus of Homberg.

Composition.

3. Chloride of calcium is composed of

Calcium	21
Chlorine	36
	57

Medical uses.

4. Chloride of calcium in a state of solution, under the name of the *water of muriate of lime*, has been recommended by several physicians in scrofula and other glandular diseases. The average dose for children is thirty drops, and for adults a drachm repeated twice or thrice a day.

Iodide of calcium.

VI. Calcium combines with iodine, and forms iodide of calcium. It may be obtained by saturating lime with hydriodic acid, and exposing the compound formed to a strong heat. In the first instance there is formed this iodide and water, by a new binary arrangement of the constituents of the acid* and of the lime. The water formed is then driven off by the strong heat which is directed to be employed. The properties and composition of this iodide have not been made out.

SECTION V.

OF BARIUM.

Barium; how obtained.

I. Barium may be obtained by submitting barytes to the same electrical agency by which lime is decomposed. It has been obtained by Dr. Clarke, by exposing barytes to the intense heat produced by the combustion of a stream of oxygen and hydrogen gases, mixed in the requisite proportion to form water.

Its properties.

II. Barium is a solid metal of the colour of silver. It melts at a temperature below redness; but is not volatilized by a heat capable of producing the fusion of plate glass. It sinks rapidly in water, and is at least four or five times as heavy as an equal bulk of that liquid.

It forms with oxygen, barytes and peroxide of barium.

III. Barium combines in two proportions with oxygen, and forms barytes and peroxide of barium. Barium, when exposed to the air, absorbs oxygen and is converted into barytes. When thrown into water, it decomposes this liquid with great rapidity, and is converted into the same alkaline body; hydrogen being at the same time evolved.

* The reader is presumed to be acquainted with the constituents of hydriodic acid; they having been mentioned under the head of hydrogen, p. 20.

Barytes will be considered hereafter under the head of alkaline salifiable bases. The peroxide of barium will be noticed in this place. CHAP. III.

The peroxide; how formed.

1. Peroxide of barium may be formed by heating dry barium in oxygen gas. The gas is absorbed very rapidly, without the emission of any light. It may be formed also, by adding barytes in excess to superoxidized hydrochloric acid. The oxygen of the acid is transferred to the barytes, which precipitates in the state of peroxide.*

Properties.

2. This peroxide has a grey colour. When thrown into water, it separates from so much of its oxygen as to be converted into barytes. When heated in hydrogen, a rapid absorption of the gas takes place, accompanied by the emission of sparks from the peroxide. Its exact composition has not been ascertained.

Barium forms a chloride.

IV. Barium combines in one proportion with chlorine, and forms chloride of barium.

1. Chloride of barium, usually called *muriate of barytes*, may be prepared very easily, by saturating carbonate of barytes with hydrochloric (muriatic) acid. The carbonic acid is liberated, and the constituents of the barytes and the acid, unite in such a way as to form the chloride in question and water. It may be formed also by heating barytes in chlorine. The barytes becomes decomposed; its barium combines with the chlorine, while its oxygen is evolved.

Its properties.

2. Chloride of barium has a pungent and disagreeable taste. It dissolves in $2\frac{1}{8}$ths of its weight of either hot or cold water. It is not altered by exposure to the air. When exposed to a heat, gradually increased, it first decrepitates, then dries, and afterwards melts; but no heat, to which it has hitherto been exposed, is capable of effecting its decomposition.

Composition.

3. It is composed of

Barium	70
Chlorine	36
	106

Is an active poison.

4. Chloride of barium exerts a very powerful action upon the animal economy. When taken into the stomach in sufficient quantities, applied to the skin, or injected into the veins, it produces death very quickly.† Its poisonous qualities, however, have not prevented its use in medicine.

* Annals of Philosophy, (Jan. 1819.)
† See Nancrede's abridgment of Orfila's work on Poisons, p. 167.

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Given in solution, in three times its weight of water, in doses of from five to ten drops, cautiously increased, it is said to have been found useful, as a deobstruent, in removing scrofulous and other tumours. It has also been used in worms, and as an external application in cutaneous eruptions. But from the present limited knowledge of the powers of this chloride, much cannot be expected from its use. Its extreme activity, however, points to the propriety of ascertaining the exact operation which it exercises on the human system, when taken in small doses. This once known, it might afterwards, perhaps, be employed in a number of diseases upon sure principles.

Iodide of barium.

V. Barium is capable of forming an iodide. It may be obtained by passing hydriodic acid over barytes, at the temperature of —4°. The barytes becomes red hot, suffers decomposition, and the resulting compound is iodide of barium. It may be formed also, by saturating barytes with hydriodic acid, and exposing the compound formed to a red heat. In the first instance an iodate of barytes is formed; this, by the subsequent exposure to heat, is converted into iodide of barium which remains fixed, and water which is driven off in the form of vapour.

SECTION VI.

OF STRONTIUM.

Strontium; how obtained.

I. STRONTIUM was obtained by Sir H. Davy, from strontian, by the same means, which were employed in the decomposition of lime and barytes.

Its properties.

II. It is a solid white metal, considerably heavier than water; and having a close resemblance to barium.

Forms with oxygen, strontian, and peroxide of strontium.

III. When strontium is exposed to air or thrown into water, it combines with oxygen and is converted into strontian. This oxide of strontium will be described hereafter as an alkaline salifiable base. Strontium is capable of forming a peroxide, as Thenard has lately ascertained. It was obtained by this chemist by adding strontian in excess to superoxidized hydrochloric acid; the strontian abstracts the excess of oxygen from the acid and falls down as a peroxide.*

Chloride of strontium.

IV. Strontium combines with chlorine, and forms chloride of strontium, usually called *muriate of strontian.*

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* Annals of Philosophy, (Jan. 1819.)

1. This chloride may be obtained by saturating carbonate of strontian with hydrochloric (muriatic) acid. It is formed in consequence of a similar decomposition to that which takes place in the formation of the chlorides of calcium and of barium, as already given. CHAP. III. How obtained.

2. It may be formed also by heating strontian in chlorine gas: the chlorine combines with the metallic base of the strontian, while oxygen is evolved. Another method.

3. Chloride of strontium has a peculiar, sharp, penetrating taste. It dissolves in two-thirds of its weight of cold water; but without limit in boiling water. It is nearly one and a half times as heavy as water. Properties. Spec. grav. 1·44.

4. It is composed of Composition.

Strontium	44
Chlorine	36
	80

V. Strontium combines with iodine, and forms iodide of strontium. This iodide may be obtained by saturating strontian with hydriodic acid, and exposing the compound formed to a violent heat in a close vessel. The hydriodate of strontian is first formed, which, by the subsequent exposure to heat, is converted into the iodide in question. Iodide of strontium.

SECTION VII.

OF MAGNESIUM.

I. Sir H. Davy first obtained this substance from magnesia, by subjecting it to the same galvanic agency by which barytes and lime had been decomposed. Magnesium first obtained by Sir H. Davy.

II. Magnesium is a solid white metal, in colour resembling silver.

III. Magnesium combines in one proportion only with oxygen, and the resulting compound is *magnesia*. This combination takes place whenever magnesium is exposed to the air, or thrown into water. Magnesia will be described hereafter, in a separate section, under the head of alkaline salifiable bases. Forms magnesia with oxygen.

IV. Magnesium combines in one proportion with chlorine, and forms chloride of magnesium, usually called *muriate of magnesia*. Chloride of magnesium.

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How obtained.

1. This chloride may be formed by heating pure magnesia in chlorine gas. The chlorine combines with the magnesium, while the oxygen is evolved. It may be prepared also by dissolving carbonate of magnesia in hydrochloric (muriatic) acid. When prepared in the manner last mentioned, the chloride is combined with water. The water owes its formation to a particular decomposition, of which the reader has had many examples already.

Present in sea water.

2. Chloride of magnesium combined with water exists ready formed in sea water, and in some mineral springs.

Properties.

3. Chloride of magnesium has a hot and biting, and extremely bitter taste. It is deliquescent in the air, and cannot be made easily to crystallize. It dissolves in rather more than half its weight of water. When exposed to a strong heat, if water be present, that liquid is decomposed, and the chloride is changed into hydrochloric (muriatic) acid and magnesia.

Spec. grav. 1·601.

4. This chloride is somewhat more than one and a half times as heavy as water.

Composition.

5. It is composed of

Magnesium	12
Chlorine	36
	48

V. Magnesium is not known to combine with any other substances already described.

SUB-CLASS II.

Second sub-class of basifiable combustibles enumerated.

This sub-class embraces those basifiable combustibles which are converted into earthy salifiable bases by combining with oxygen. They are, 1. Yttrium; 2. Glucinum; 3. Aluminum; 4. Zirconium; 5. Thorinum; 6. Silicum. These bodies will form the subjects of the six following sections.

SECTION I.

OF YTTRIUM.

Yttrium: how obtained.

I. Very little can be said under the head of Yttrium. Sir H. Davy succeeded in the decomposition of the earthy salifiable base yttria, by passing potassium over it, when heated to redness: the potassium was converted into potash, and a number of metallic particles were developed. From the result of this experiment, there can be no doubt that

yttria was decomposed; but its base was obtained in quantities too small to admit of accurate examination. Chap. III.

II. At present the only substance known to be capable of combining with yttrium is oxygen; and the result of the combination is yttria. Yttria will be described hereafter under the head of earthy salifiable bases. Combined with oxygen forms yttria.

SECTION II.

OF GLUCINUM.

I. Glucinum was obtained from the earthy salifiable base glucina, by heating it in contact with potassium. The potassium became converted into potash, and a number of dark coloured metallic particles were developed. These particles were considered to consist of a peculiar metal, which was accordingly called glucinum. Glucinum: how obtained.

II. Glucinum, when thrown into water, decomposes that liquid, combines with oxygen, and is converted into glucina. Synthesis, therefore, as well as analysis, goes clearly to show that *glucina* is an *oxide* of *glucinum*. Glucina will be described hereafter under the head of earthy salifiable bases. Forms glucina by combining with oxygen.

SECTION III.

OF ALUMINUM.

I. Sir H. Davy was led, from analogy, to suspect that alumina (in an impure state called clay) like the other earthy salifiable bases, was a compound of a metallic body and oxygen; and he verified this suspicion by passing potassium over alumina heated to whiteness. The potassium became converted into potash, and a peculiar metallic substance was developed, which, when thrown into water, combined with oxygen, and produced alumina. The fair conclusion to be drawn from these facts is, that alumina is composed of the peculiar metal thus obtained and oxygen. It is this peculiar substance which is called aluminum. Aluminum: how obtained.

II. Aluminum has not been obtained in sufficient quantities to enable the chemist to give it an accurate examination. The only combination into which it is known to enter is that with oxygen, which results in the formation of alumina, as already stated. Alumina will be described hereafter, under the head of earthy salifiable bases. Its properties, not ascertained. Combined with oxygen forms alumina.

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SECTION IV.

OF ZIRCONIUM.

Zirconium: how obtained.

I. Zirconium was exposed by Sir H. Davy to the same agents of decomposition, by which the other earthy salifiable bases were decomposed; and it gave similar indications of being a compound of a peculiar metallic body and oxygen. Zirconium is the name applied to this peculiar substance.

Forms zirconia in combination with oxygen.

II. It has not been possible heretofore to make out the properties of this metal. The only substance with which it is known to combine is oxygen, with which it forms zirconia. Zirconia will be described hereafter under the head of earthy salifiable bases.

SECTION V.

OF THORINUM.

Thorinum, the supposed radical of the earthy salifiable base thorina.

I. Berzelius has discovered, in a mineral found in Sweden, an incombustible body, which has all the properties of an earthy salifiable base. He has given to it the name of thorina. There can be very little doubt that this body is similarly constituted to those usually called *earths*, and consequently that it is a metallic oxide. Depending upon the evidence of this close analogy, Berzelius has assigned to it a metallic base, which he calls *thorinum*. Thorinum, therefore, is a hypothetical substance; and is introduced here for the sake of perspicuity, and to avoid the anomaly in arrangement of placing thorina in the same class with azote; which position it would have to assume upon the supposition that it was not a compound.

II. Thorina will be described hereafter, under the head of earthy salifiable bases.

SECTION VI.

OF SILICUM.*

Silicum: how obtained.

I. Silicum was first obtained, through the agency of galvanic electricity, from silica (pure flint) by professor

* Dr. Thomson places silicum among the acidifiable combustibles; because he believes that sufficient reason has been given for supposing that silica (oxide of silicum) performs the part of an acid. In this particular I have not followed Dr. Thomson; not being satisfied that its close analogy to acids has been well made out. There are indeed some circumstances with regard to silica, in which it differs particularly from all the other earthy salifiable bases; but these do not call for the measure of associating it with acids, where it cannot stand without violating the obvious and natural analogies of chemical bodies.

Berzelius of Sweden. It was, however, in a state of alloy with iron. It was afterwards obtained in a separate state, by Sir H. Davy, by passing potassium in excess over heated silica, contained in a platinum tube. But the quantities in which it was obtained were too small to enable this chemist to make out many of its properties.

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Forms silica, united to oxygen.

II. Silicum, obtained by Sir H. Davy's method, appears in the form of a dark coloured powder. It seems capable of bearing a very high temperature without alteration. When thrown into water, it decomposes that liquid, combines with oxygen, and is converted into silica. Silica will be described hereafter, under the head of earthy salifiable bases.

Supposed to form an acid with fluorine.

III. Silicum, combined with fluorine, is supposed to constitute the peculiar acid called fluosilicic acid. It is formed by the distillation of fluor spar with sulphuric acid in glass vessels. It will be described hereafter under the altered name of silicofluoric acid.

SUB-CLASS III.

Basifiable combustibles of the third sub-class, enumerated.

This sub-class of basifiable combustibles comprises those which form, by combining with oxygen, salifiable bases, which have neither alkaline nor earthy properties. They are the following:

1. Iron; 2. Nickel; 3. Cobalt; 4. Manganese; 5. Cerium; 6. Uranium; 7. Zinc; 8. Lead; 9. Tin; 10. Copper; 11. Bismuth; 12. Mercury; 13. Silver; 14. Gold; 15. Platinum; 16. Palladium; 17. Rhodium; 18. Iridium; 19. Osmium; 20. Titanium.

All these combustibles are metals. They will be described in the order in which they have been named in the following sections.

SECTION I.

OF IRON.

Process for obtaining iron pure.

I. Iron may be obtained pure by the following process: Treat the mineral called *pyrites*, which is a sulphuret of iron, repeatedly with boiling nitric acid. By this measure the sulphur becomes acidified and the iron oxidized; so that the sulphuret is changed into a sulphate of iron. Decompose this sulphate by means of hydrochloric (muriatic) acid: this acid separates the sulphuric acid, and combines with the oxide of iron, leaving the impurities untouched. To the solution as it now stands, add chloride of barium (muriate of barytes): water is immediately decomposed; the barium

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is converted into barytes, which, combining with the sulphuric acid, forms the insoluble compound called sulphate of barytes; while the chlorine combines with hydrogen, and is changed into hydrochloric (muriatic) acid. After separating the insoluble sulphate of barytes by the filter, nothing remains but a solution of pure oxide of iron in hydrochloric (muriatic) acid. To this solution add a solution of carbonate of soda (common soda): a double decomposition instantly takes place; the carbonic acid and oxide of iron combine and form the insoluble compound called carbonate of iron; while the hydrochloric acid and soda unite so as to form chloride of sodium (common salt) and water. Separate the carbonate of iron by the filter, and after being washed and dried, expose it to the action of a strong red heat: the carbonic acid is driven off, the oxide is reduced, and a button of pure iron is obtained.

Iron, extracted from its ores, obtained in the form of cast iron.

II. When iron is separated from its ores by the manufacturer, the process is very different from that just given; and the result is the production of the metal in a state very far from being pure. It is called *cast iron*, and owes its peculiar properties to the presence of carbon.

Process for obtaining cast iron.

1. The ore from which cast iron is obtained is generally a mixture of oxide of iron and clay. It is reduced to small pieces, mixed with charcoal and limestone (carbonate of lime) and exposed to a violent heat in a furnace, whereby the whole becomes melted. After remaining in fusion for a sufficient time, a hole is opened in the lower part of the furnace and the iron runs out.

Process explained.

2. In the above process the use of the limestone and charcoal may be thus explained. At the high temperature to which the ore is raised, the oxygen which it contains, combines with the charcoal and flies off in the form of carbonic acid. On the other hand the lime of the limestone combines with the clay and forms a kind of liquid glass. This fused compound being lighter than the iron, swims on the surface. In this way both the substances, with which the metal is combined in the ore, are separated. The opening made in the lower part of the furnace allows the iron to run out unmixed with the supernatant impurities.

3. If the iron ore contain sulphur and arsenic, these substances are to be driven off by exposure to a sufficient heat. This process is called roasting.

Cast iron is either; 1. White cast iron; 2. Grey cast iron; or

4. Cast iron, according to its colour, is distinguished into several kinds. *White cast iron* is very hard and brittle; not susceptible of being filed, bored or bent, and very liable to break when suddenly cooled. *Grey or mottled cast iron* has a granular texture, and is not nearly so hard or brittle as

the preceding kind. It may be cut, bored, or turned on a lathe. Artillery are manufactured from this kind of cast-iron. *Black cast iron* is the most variable in its texture of all the species of cast iron. It is more fusible and less coheasive than the other varieties. Cast iron melts when heated to about 130° of Wedgewood's pyrometer.* Upon fusion it contracts considerably, contrary to the usual effects of heat. It is between seven and seven and a half times as heavy as water.

3. Black cast iron.

Different var. of cast iron contain different proportions of carbon.

5. Besides carbon, cast iron contains oxide and phosphuret of iron, and silica. It has been found by experiment that

White cast iron	contains about	$\frac{1}{25}$th of its weight of carbon.
Grey cast iron		$\frac{1}{20}$th ————————
Black cast iron		$\frac{1}{15}$th ————————

Cast iron; how converted into malleable iron.

6. Cast iron may be converted into malleable iron by the following process: Melt it in a reverberatory furnace,† and make the flame of the fuel play upon its surface. Stir it constantly, so as to bring successively every portion of the iron in contact with the air. After the stirring has continued one hour, the melted metal begins to heave and swell, and to emit a blue lambent flame. As the process advances, it acquires more and more consistency. After it has been in this state for another hour it suddenly congeals into a soft mass. In this state, while yet hot, it is beaten by a heavy hammer. The cast iron is now converted into malleable iron.

This conversion explained.

7. The conversion of cast iron into malleable iron may be thus explained. By constantly stirring the cast iron, while the flame of the furnace is made to play upon its surface, the charcoal which it contains is gradually burnt out. As this separation advances the metal becomes less and less fusible; and this is the cause of its gradually acquiring consistency. When it congeals it is the pure iron only, which takes the solid form; the cast iron, still in a state of fusion, remaining in its interstices. The object therefore of the subsequent hammering is obvious; it drives out the fused cast iron, and forces the particles of pure iron together, so as to form a solid mass. Cast iron, by undergoing this process for conversion into malleable iron, looses more than one-fourth of its weight.

Properties of pure iron.

III. Iron, when pure, possesses the following properties. It has a bluish white colour and fibrous texture. When

* An instrument for measuring high degrees of heat, invented by Wedgewood. It will be described hereafter.

† A furnace whose body is covered with a dome, which terminates in a chimney.

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polished it possesses considerable brilliancy. It has a styptic taste, and emits a peculiar smell when rubbed. It is ductile, flexible and malleable. Its hardness is considerable, and its tenacity very great. When perfectly pure, it is not susceptible of the magnetic impression. It melts when heated to the temperature of 158° of Wedgewood.

Spec. grav. from 7·6 to 7·8.

IV. It is about seven and a half times as heavy as water.

V. It may be made to burn in the following manner. Plunge into a jar containing oxygen gas, a small iron wire, to one extremity of which a small piece of cotton, in a state of inflammation, is attached: the iron wire catches fire and burns with a vivid flame.

Iron forms two oxides.

VI. Iron combines in two proportions with oxygen, and forms protoxide and peroxide of iron.

1. Protoxide of iron.

PROTOXIDE OF IRON.

Former names, *Martial Ethiops.—Scales of Iron.*

How obtained.

1. This oxide may be obtained by dissolving iron in sulphuric acid (oil of vitriol) and pouring into the solution thus formed, a solution of potash. The acid converts the iron into this oxide, at the expense of the water which it contains, and then dissolves it: the added potash, having a stronger tendency to combine with sulphuric acid, than the oxide of iron has to retain it, combines with the former, while the latter, being insoluble, falls in the form of powder.

Other methods.

2. Protoxide of iron may be obtained by several other methods. It is formed when iron filings are kept under water, for a sufficient length of time, at a temperature above 70°. When iron is subjected to a red heat, its surface becomes converted into this protoxide; so that the scales, which are driven off from red hot iron struck on the anvil, consist of this oxide. This same oxide is formed also during the combustion of iron.

Properties of this protoxide.

3. Protoxide of iron is a black tasteless powder, insoluble in water. When newly precipitated, however, it is green, but becomes black by being dried quickly in close vessels. Its solutions in acids have a pale green colour, and a sweetish astringent taste.

Composition.

4. Protoxide of iron is composed of

Iron	28
Oxygen	8
	36

Used in medicine.

5. Protoxide of iron is used in medicine, with a view to its tonic properties. But for this purpose, carbonate of iron (rust of iron) is preferable.

PEROXIDE OF IRON.

2. Peroxide of iron.

Red Oxide of Iron of the Ed. College.—Formerly called *Saffron of Mars.*

How obtained.

1. This oxide may be obtained by exposing a diluted solution of iron in sulphuric acid, for a long time, to the atmosphere, and then adding to it a solution of potash: a powder precipitates, which consists of the oxide in question.

Process explained.

2. By the exposure of a solution of iron in sulphuric acid to the air, the protoxide, which at first exists in it, is gradually changed into the peroxide of iron by the absorption of oxygen. A solution of potash, added to the solution of iron thus changed, combines with the sulphuric acid and throws down the peroxide.

Another process.

3. Peroxide of iron may be formed also, by exposing iron filings to a red heat, and subjecting them to constant agitation. Oxygen is absorbed, and the iron converted into this oxide.

Properties of the peroxide.

4. Peroxide of iron is a tasteless and insoluble powder of a fine red colour, with a shade of yellow. Its solutions in acids have a brownish or yellowish colour and a sweet astringent taste.

Composition.

5. It is composed of

Iron	56
Oxygen	24
	80.

—So that it appears that this oxide contains one and a half times as much oxygen as the protoxide; or, which is the same thing, three times as much oxygen united to twice as much iron.

Used in medicine.

6. Peroxide of iron agrees pretty much in medical properties, with the protoxide.

Iron forms two chlorides.

VII. Iron combines in two proportions with chlorine and forms protochloride and perchloride of iron.

1. Protochloride: how obtained.

1. *Protochloride of iron* may be obtained by dissolving iron in hydrochloric (muriatic) acid, evaporating the solution to dryness, and then exposing it to a red heat without the contact of air. The mass obtained is this chloride. In the process, hydrochlorate of iron is first formed; which, upon exposure to a red heat, is converted, by a new arrangement of its constituents, into the chloride under description which remains fixed, and water which is driven off in a state of vapour.

Its properties.

2. Protochloride of iron has a variegated grey colour, and a lamellated texture. It possesses the metallic lustre. When heated to redness it fuses, but does not volatilize. When dissolved in water it combines with the constituents

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of that liquid in such a manner as to form hydrochlorate (green muriate) of iron.

Composition.

3. It is composed of

Iron	28
Chlorine	36
	64

2. Perchloride: how obtained.

1. *Perchloride of iron* may be obtained by evaporating perhydrochlorate (red muriate) of iron to dryness, and afterward heating it in a tube furnished with a narrow orifice. It may be formed also by burning iron wire in chlorine gas. The product of the combustion is this chloride.

Its properties.

2. Perchloride of iron has a bright brown colour. It is volatilized at a moderate heat, and may be made to deposite in minute brilliant crystals. When dissolved in water, it combines with the constituents of this liquid in such a manner as to be converted into perhydrochlorate (red muriate) of iron.

3. It is composed of

Iron	28
Chlorine	53*
	81

Iodide of iron.

VIII. Iron combines in one proportion with iodine and forms iodide of iron. It may be formed by heating iron in the vapour of iodine.

Iron forms several carburets.

IX. Iron combined with carbon, forms different carburets of iron. The principal ones are known by the names of plumbago and steel. These substances will be noticed in the order in which they have been named.

1. Plumbago.

PLUMBAGO.

Syn. *Black Lead.—Graphite.*

Found native in abundance.

1. This carburet is never formed artificially by the chemist. It occurs abundantly native in different parts of the world. The plumbago, of which black lead pencils are manufactured, is the product of the mine of Barrowdale in the county of Cumberland, England. It is said that this is the only mine which furnishes black lead fit for the formation of pencils. Plumbago is employed for making crucibles.

Properties of plumbago.

2. Plumbago has a dark steel grey colour. It possesses the metallic lustre. It is soft and has a greasy feel. When kept at a red heat in the open air it gradually wastes away. It contains about one-twentieth of its weight of iron.

2. Steel: its general properties.

STEEL.

1. Steel has the following general properties, which apply more or less to all its varieties. It is brittle, and so hard as to resist the action of the file. It strikes fire with flint, and

is capable of retaining the magnetic virtue for any length of time. It is malleable at a red heat, but scarcely so at a white one. It may be hammered into much thinner plates than iron. Its melting point is at the temperature of 130° of Wedgewood. When hammered it is somewhat more than seven and a half times as heavy as water.

CHAP. III.

Spec. grav. from 7·78 to 7·84.

2. Steel may be easily distinguished from iron by dropping upon it a little nitric acid. This acid will form a black stain upon steel, occasioned by the carbon which it developes, but it causes a whitish green mark upon iron.

How distinguished from iron.

3. Steel has the property of becoming much harder by being heated to redness, and then plunged into cold water. Cutting instruments are submitted to this process of hardening after they are made. But afterwards this hardness must be lessened; otherwise a fine and durable edge could not be given to the instrument. The process of softening steel a little is called *tempering*, and is performed by heating it until it assume some particular colour, when it is plunged into water.

Method of hardening steel.

4. Cutting instruments require different degrees of hardening according to the use for which they are intended. A different hardness is produced for every colour, which the steel is made to assume, before being plunged into water. These colours occur in regular succession in proportion as the heat advances, and are the indications of particular temperatures. When the heat is raised to the temperature of from 400° to 450°, the colour which the steel assumes is a very pale yellow. At 460° it is a straw yellow. This colour gradually deepens, until the temperature reaches 500°, when it becomes a bright brownish metallic yellow. If the heat be still farther increased, the surface of the steel becomes yellow, brown, red and purple successively, until the temperature reaches 580° when the colour becomes uniformly deep blue. By a farther increase of temperature, this colour gradually weakens until at last the red heat is produced.

Process for producing different degrees of hardening explained.

5. There are several varieties of steel; the principal of which are *natural steel*, *steel of cementation** and *cast steel*. These varieties will be noticed in the following paragraphs.

Principal varieties of steel are

a. Natural steel is formed by exposing cast iron in a furnace, for a considerable time, to a violent heat, covered with a mass of melted scoriæ, five or six inches deep. Steel contains less carbon than cast iron; and this conversion is

natural steel:

* Cementation is a process which consists in the surrounding of one body with the powder of some other, and exposing the whole to a strong heat, but not sufficient to produce fusion. The body so treated becomes changed in its properties.

supposed to consist in the separation of a part of the carbon from the latter. This is considered to be effected, during the violent heat, by the combination of the carbon of the cast iron with the oxygen which it also contains, which results in the formation of carbonic acid.

Natural steel is not throughout of uniform quality. It is softer and less brittle than the other kinds of steel, and is the cheapest and least valuable variety.

steel of cementation, or blistered steel: and

b. Steel of cementation, called also *blistered steel*, is formed by stratifying bars of pure iron and charcoal powder alternately, in large earthen troughs, whose mouths are accurately closed; and exposing them in a furnace, to heat for eight or ten days. At the end of this time, the bars are converted into blistered steel. The process by which this steel is formed was first practised to any extent in Britain.

This variety of steel has a fine grain and a uniform texture. It is much harder and more elastic than natural steel. It is called *blistered* from the appearance of its surface, which is covered with marks like blisters, which had evidently been produced by the escape of some elastic fluid. This steel, when drawn into smaller bars by means of the hammer, is called *tilted steel*. When broken into pieces and repeatedly welded, it has the name of *German* or *Shear steel*.

cast steel.

c. Cast steel is formed by fusing blistered steel in a close crucible, along with pulverized glass and charcoal powder. This variety of steel has the closest texture and admits of the highest polish of all the kinds of steel. It is for these reasons that it is preferred in the manufacture of razors, and for surgical instruments. It is more fusible than common steel, and therefore cannot be welded with iron.

Steel owes its peculiar properties to the presence of carbon.

6. All the varieties of steel are combinations of iron with small proportions of carbon; hence they are, in the technical language of chemistry, *carburets* of iron. Cast steel contains the largest proportion of carbon, which amounts to not more than one per cent.

Phosphuret of iron: how obtained.

X. Iron combines with phosphorus and forms phosphuret of iron.

1. This phosphuret may be obtained by fusing, in a crucible, a mixture of equal parts of phosphoric acid and iron with a portion of charcoal powder. The acid is reduced to the state of phosphorus, by yielding up its oxygen to the charcoal, and then combines with the iron. It was discovered by Bergman, by whom it was mistaken for a new metal, and called *siderum*.

Properties.

2. Phosphuret of iron is a brittle substance; and its fracture exhibits a white colour. When exposed to a strong heat, it melts and the phosphorus is dissipated.

3. The particular kind of iron called *cold short*, which is brittle when cold, but when hot malleable, derives its peculiar qualities from the presence of phosphate of iron. It was this compound, after being converted into a phosphuret by the attempts for its reduction, which Bergman mistook for a peculiar metal.

Chap. III. Chemical nature of cold short iron.

XI. Iron combines in two proportions with sulphur and forms protosulphuret and persulphuret of iron.

Iron forms with sulphur, 1. a protosulphuret; and

1. *Protosulphuret of iron* (magnetic pyrites) need not be formed by the chemist. It occurs abundantly native in different parts of the world. It has a bronze colour and the metallic lustre. When reduced to powder, it has a blackish grey colour. It strikes fire with steel and is susceptible of the magnetic virtue. Its point of fusion is low. It is somewhat more than four and a half times as heavy as water.

2. It is composed of

Iron	28
Sulphur	16
	44

1. *Persulphuret of iron* (cubic pyrites) is also found native in abundance. It has a yellow colour and possesses the metallic lustre. It is brittle and strikes fire with steel. It is about four and a half times as heavy as water.

2. a persulphuret.

2. It is composed of

Iron	28
Sulphur	32
	60

—So that it appears that this sulphuret contains twice as much sulphur as the protosulphuret.

XII. Iron is employed for the cure of diseases in a number of forms; and its general properties are those of a powerful astringent and tonic. It is not unfrequently given in the metallic state, in the form of iron filings; but it is considered as inert, unless oxidized in the stomach. The dose of the filings is from five to twenty grains.

Medical uses of iron.

SECTION II.

OF NICKEL.

I. Nickel may be obtained by the following process: Dissolve the nickel of commerce, in which the metal ex-

Nickel; how obtained pure.

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ists alloyed by several others, in sulphuric acid, assisting the solution by the addition of some nitric acid. Concentrate the solution, and let it stand for several hours. Green crystals of sulphate of nickel will be observed to form. This treatment must be repeated until a sufficient number of these crystals are obtained. Dissolve them in water, and drop into their solution, a solution of potash or of soda. This addition precipitates the nickel in the state of oxide. The oxide may be deoxidized by being made into a paste with oil, and exposed in a charcoal crucible to a very violent heat. The oxygen flies off in combination with the charcoal, so that nothing remains but the pure metal.

Its ores, where found.

II. The ores of nickel are found, for the most part, in Germany. That which occurs most abundantly is called *kupfernickel*, or false copper, from its resemblance to the ores of copper. It is composed principally of nickel and arsenic.

Its discovery.

III. Nickel was discovered in 1751 by Cronstedt, by whom it was called by its present name.

Properties of nickel.

IV. Nickel has a fine white colour, resembling silver. Its hardness is considerable, but less than that of iron. It is malleable when either hot or cold. Like steel it may be converted into a magnet. It is not altered by exposure to air or immersion in water. Its fusing point is at least as high as 160° of Wedgewood.

Spec. grav. 8·402.

V. It is somewhat less than eight and a half times as heavy as water. Its weight is considerably increased by hammering.

Nickel forms

VI. Nickel combines in two proportions with oxygen, and forms protoxide and peroxide of nickel.

1. a protoxide, and

1. *Protoxide of nickel* may be obtained by dissolving nickel in nitric acid, and adding potash to the solution thus formed. The nickel is thrown down in the state of this oxide.

2. Protoxide of nickel has a blackish ash-grey colour, but no taste. Its solutions in acids have a grass green colour. It forms a pale blue coloured solution with ammonia.

3. It is composed of

Nickel	27
Oxygen	8
	35

2. a peroxide.

1. *Peroxide of nickel* may be obtained by the following process: Pass a current of chlorine gas through water, in which protoxide of nickel is suspended: water becomes decomposed; its hydrogen combines with the chlorine, forming hydrochloric (muriatic) acid, while its oxygen unites to a portion of the oxide, so as to change it from protoxide to

peroxide. The peroxide thus formed, being insoluble, is easily separated. The unaltered portion of the oxide dissolves in the hydrochloric acid.

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2. Peroxide of nickel has a black colour. It dissolves in ammonia with effervescence, yielding up at the same time part of its oxygen, which combines with the hydrogen of the ammonia, the azote of the latter being evolved. Its solution in acids is attended with effervescence also; owing to the evolution of oxygen, during its conversion into protoxide.

3. It is composed of

Nickel	54
Oxygen	24
	78.

—Thus this oxide contains one and a half times as much oxygen as the protoxide; or, which is the same thing, twice as much nickel, united to three times the quantity of oxygen.

Chloride of nickel.

VII. Nickel combines in one proportion with chlorine, and forms chloride of nickel. This chloride cannot be formed by combustion; but it may be obtained by subliming dry hydrochlorate (muriate) of nickel. Its properties and composition have not been ascertained.

Phosphuret.

VIII. Phosphuret of nickel may be formed by dropping phosphorus upon metallic nickel, while at a red heat. It is a very brittle and moderately hard substance of a tin white colour. It possesses the metallic lustre.

Sulphuret.

IX. Sulphuret of nickel may be formed by fusing together its constituents. It has a yellowish white colour.

SECTION III.

OF COBALT.

Cobalt; how obtained pure.

I. COBALT may be obtained by the following process: Treat, by the assistance of heat, one part in powder of the ore of cobalt, in which the metal exists mineralized by arsenic, iron and sulphur, with three parts of aqua regia, as long as any portion of it is dissolved. The aqua regia dissolves all the ore except the sulphur. Filter the liquid obtained, in order to separate the insoluble part, and add to it, a solution of carbonate of potash, as long as it causes any precipitate. This precipitate consists of cobalt combined with iron and arsenic. Separate it by the filter, dissolve it in nitric acid and add ammonia. This step in

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the process throws down the metals in combination with ammonia. The metals, by being in this state of combination, are rendered soluble in acetic acid (pure vinegar). Accordingly dissolve the precipitate last formed in acetic acid, and evaporate the solution until it let fall a red powder: this powder will prove to be oxide of iron. After it is separated, the remaining solution consists of acetate of cobalt contaminated with arsenic. In order to separate the arsenic add liquid ammonia. The ammonia combines with the cobalt and remains in solution, while the arsenic falls. The arsenic being separated by the filter, nothing remains but an ammoniacal solution of cobalt. Evaporate this solution to dryness, to drive off the ammonia, and expose the dry mass, being oxide of cobalt, mixed with three parts of black flux and one part of borax, to a violent heat in a crucible. The oxygen becomes separated by the flux, and there is obtained a metallic button of cobalt.

Where found.

II. Cobalt is found principally in Germany, Sweden, Norway and Hungary, mineralized usually by arsenic, iron and sulphur. It has occasionally been found combined with sulphuric and arsenic acids.

Its discovery.

III. Cobalt was discovered in 1733 by the Swedish chemist Brandt, by whom it was called by its present name.

Properties of cobalt.

IV. Cobalt is of a grey colour with a shade of red. It is rather soft, and has very little metallic brilliancy. It has scarcely any taste or smell. It undergoes no change from exposure to air or immersion in water. Its fusing point is at the temperature of 130° of Wedgewood.

Spec. grav. 8·53.

V. It is a little more than eight and a half times as heavy as water.

Cobalt forms two oxides.

VI. Cobalt unites in two proportions with oxygen, and forms protoxide and peroxide of cobalt.

1. Protoxide.

1. *Protoxide of cobalt* may be obtained by dissolving cobalt in nitric acid, and precipitating the solution by means of potash. The precipitate must be washed and dried, and exposed to a cherry red heat, to drive off the oxygen, which it will have absorbed during the process of drying; it is then pure protoxide of cobalt.

Its properties.

2. This oxide has a fine blue colour. It dissolves in acids without effervescence. Its solution in hydrochloric (muriatic) acid, when concentrated is blue, but when diluted, red. In sulphuric or nitric solutions, it is always red. It enters into the composition of the salts of oxidized cobalt.

3. Protoxide of cobalt is composed of

Cobalt	29
Oxygen	8
	37

1. *Peroxide of cobalt* may be formed by heating the protoxide in the open air. The protoxide absorbs oxygen and becomes converted into peroxide. CHAP. III. 2. Peroxide.

2. This oxide has a black colour. It gives out part of its oxygen with effervescence, when dissolved in hydrochloric (muriatic) acid; chlorine being at the same time evolved. It does not enter into the composition of salts. Its properties.

3. Peroxide of cobalt is composed of

Cobalt	58
Oxygen	21*
	79.

—When this oxide is compared with the protoxide as to composition, it will be perceived that it contains twice as much cobalt, combined with somewhat less than three times as much oxygen. So that the numbers of the two oxides do not admit of any exact comparison.

VII. Chloride of cobalt may be formed by burning cobalt in chlorine gas. It has not been examined with accuracy. Chloride of cobalt.

VIII. Phosphuret of cobalt may be formed by heating the metal red hot, and dropping into it small pieces of phosphorus. It is a white and brittle substance, which soon tarnishes in the air. It contains about $\frac{1}{15}$th of its weight of phosphorus. Phosphuret.

IX. Sulphuret of cobalt may be formed by melting the metal with sulphuret of potash: the sulphur combines with the metal, and the potash is separated. It has a yellowish white colour. Its composition is not accurately known. Sulphuret.

SECTION IV.

OF MANGANESE.

I. MANGANESE may be obtained by the following process: Make up the black oxide of manganese, finely powdered, into a ball with pitch. Put it into a crucible lined with charcoal, and filled with charcoal powder. Close the crucible with a cover, which must be well luted on. The whole must then be exposed, for an hour, to the strongest heat that can be raised. A small button of the metal will be found in the bottom of the crucible. Manganese how obtained pure.

II. Manganese, almost always in the state of oxide, is found abundantly distributed in different parts of the world; particularly in France, Spain, Germany and England. Where found.

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Discovery. III. About the year 1770, several chemists suspected that the mineral called *manganese* was a metallic oxide; and Kaim published a set of experiments to prove that a metal might be obtained from it. Numerous attempts were made to reduce it to the metallic state, which were unsuccessful, until Gahn invented the process which has just been described.

Properties of manganese. IV. Manganese has a greyish white colour, resembling that of cast iron, and considerable brilliancy. It has neither taste or smell. It is softer than cast iron and yields to the file. It is very brittle, and its fracture is uneven and fine grained. In the air, it loses its lustre; becoming successively grey, violet, brown and at last black. When thrown into water it decomposes that liquid with considerable rapidity; hydrogen being at the same time evolved. Its fusing point is at the temperature of 160° of Wedgewood.

Spec. grav. 8 013. V. It is very little more than eight times as heavy as water.

Manganese forms three oxides. VI. Manganese combines in three proportions with oxygen, and forms protoxide, deutoxide and peroxide of manganese.

1. Protoxide. 1. *Protoxide of manganese* may be obtained by dissolving the mineral called *manganese* in an acid, and precipitating the solution by potash. The precipitate which appears consists of this oxide. It is an olive-green powder, which becomes black upon exposure to air, in consequence of the absorption of oxygen. It is this oxide generally, which enters into the composition of the salts of oxidized manganese.

2. It is composed of

Manganese	28
Oxygen	8
	36

2. Deutoxide. 1. *Deutoxide of manganese* may be formed by exposing nitrate of manganese to heat; or by burning the protoxide in the open air. It has a black colour.

2. It is composed of

Manganese	56
Oxygen	24
	80

—So it appears that this oxide contains three times as much oxygen, united to twice as much manganese, as the protoxide.*

* Thomson's Annals, xi. 228. (Mar. 1818.)

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3. Peroxide.

1. *Peroxide of manganese* (black oxide of manganese) need never be formed by the chemist. It occurs abundantly native, particularly in the county of Devonshire, England. When pure it has a radiated texture, and a dark steel-grey colour. Its lustre is considerable. It is brittle, very soft, and soils the fingers. It is about four and three-fourths as heavy as water. When heated to redness, it is converted into a red powder, which, by treatment with acids, immediately separates into protoxide and deutoxide.* Hence it is probable that this powder is a mixture of these oxides.

2. Peroxide of manganese is composed of

Manganese	28
Oxygen	16
	44

—so that it contains twice as much oxygen as the protoxide.†

Manganese forms a chloride.

VII. Manganese combines in one proportion with chlorine, and forms chloride of manganese.

1. This chloride was first obtained by Dr. John Davy, by dissolving peroxide of manganese in hydrochloric (muriatic) acid, evaporating the solution to dryness, and exposing the dry mass, thus obtained, to a red heat in a glass tube with a narrow orifice.

Its properties.

2. Chloride of manganese has a delicate pink colour, and a lamellar texture. When exposed to the open air, it deliquesces, and is converted into hydrochlorate (muriate) of manganese.

3. It is composed, in whole numbers, of

Manganese	28
Chlorine	33*
	61

Phosphuret of manganese.

VIII. Phosphuret of manganese may be formed by dropping phosphorus upon red hot manganese. It is a white brittle substance of a granular texture. It is not altered by exposure to air. It fuses much more readily than manganese.

Sulphuret.

IX. Sulphuret of manganese may be formed by heating sulphur and manganese together. Its properties and composition have not been accurately made out.

* Thomson's Annals, xi. 228. (March, 1818.)—† Ibid.

SECTION V.

OF CERIUM.

Cerium; how obtained pure.

I. Cerium may be obtained by the following process:—Digest the mineral called *cerite* (a compound of oxide of cerium, silica, and oxide of iron) in fine powder in nitric acid, until every thing soluble is taken up. The nitric acid dissolves the oxides, and leaves the silica untouched, which appears in the form of an insoluble residue. Decant the clear solution from this residue, and add to it oxalic acid, as long as any precipitate appears. This acid falls in combination with the oxide of cerium, while the oxide of iron still remains in solution. Separate this precipitate, and, after being washed and dried, expose it to a red heat. The oxalic acid is decomposed and driven off, and a red powder is obtained, which is cerium in the state of oxide. The reduction of the oxide to the metallic state, by means of carbonaceous substances, is attended with great difficulty, and is accomplished, under the most favourable circumstances, in an imperfect manner only. Sir H. Davy, however, succeeded in obtaining the metal pure, by heating the oxide in contact with potassium. The potassium becomes converted into potash, and the pure metal is developed.

Where found.

II. Cerium has been found hitherto principally in Sweden. It occurs combined with silica and iron, in the mineral called *cerite;* and also with hydrofluoric (fluoric) acid, yttria, and thorina, in several other minerals.

Account of its discovery.

III. Before the discovery of the metallic nature of the earthy salifiable bases, it remained for some time doubtful whether the powder obtained from *cerite* was an earth or a metallic oxide. Klaproth supposed it was an earth; and Vauquelin was in doubt which of the two to consider it. Hisinger and Berzelius obtained the same peculiar powder from the mineral, and considered it a metallic oxide: but these chemists were unable to reduce it to the metallic state. Vauquelin re-examined the powder, with the view to reduce it, if possible. These attempts, although unsuccessful, were sufficient to demonstrate its metallic nature. It was ultimately reduced by Sir H. Davy in the manner already mentioned.

Properties of cerium.

IV. Cerium has been but very imperfectly examined. According to Sir H. Davy, it is a deep-grey metallic powder.

Forms two oxides.

V. Cerium forms, with oxygen, a protoxide and a peroxide. The former is white; the latter reddish-brown.

No accurate analysis has been made of them. They both enter into the composition of the salts of oxidized cerium. Chap. III.

SECTION VI.

OF URANIUM.

I. Uranium may be obtained from *pechblende* (a mineral in which the metal exists in the state of oxide, mixed with sulphuret of lead, oxide of iron, and silica) by the following process: Roast the mineral for some time, in order to drive off the sulphur; and then digest it in nitric acid, until every thing soluble is taken up. The acid dissolves the metals, and leaves the silica. Decant the clear solution, and add to it carbonate of potash as long as any precipitate appears: this precipitate consists of oxide of uranium, united to carbonic acid. Separate it, and, after being washed and dried, expose it, made up into a paste with oil, in a crucible lined with charcoal, to a violent heat. The carbonic acid is driven off, and the oxygen of the oxide separated; so that nothing remains but pure uranium. Uranium; how obtained pure.

II. Uranium is found in the state of oxide, mixed with small quantities of iron, lead, and copper, in ores which occur in Germany, Norway, France, and England. Where found.

III. It was discovered in 1789, by Klaproth, by whom it was called by its present name.

IV. Uranium is a metal, having an iron-grey colour, and considerable lustre. It is soft enough to yield to the file. Its properties.

V. It is somewhat more than eight times as heavy as water. Spec. grav. 8·100.

VI. Uranium forms, with oxygen, a protoxide and peroxide; both of which have the property of neutralizing acids. Forms two oxides.

1. *Protoxide of uranium* may be formed by heating the metal to redness in an open vessel. It glows like a live coal, absorbs oxygen, and is converted into a powder, which consists of this oxide. Its colour is greyish black. 1. Protoxide.

2. It is composed of

Uranium	125
Oxygen	8
	133

1. *Peroxide of uranium* may be obtained by dissolving uranium in nitric acid, and precipitating the solution by potash. The precipitate which appears is the oxide in question. It has a yellow colour. Chevreul has noticed that 2. Peroxide.

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the air. When dissolved in water, it decomposes this liquid, and is converted into hydriodate of zinc. It is composed of

Zinc	33
Iodine	125
	158

Phosphuret.

VIII. Phosphuret of zinc may be formed by dropping small pieces of phosphorus into melted zinc. It has a white colour and the metallic lustre. It possesses some degree of malleability.

Sulphuret.

IX. Sulphuret of zinc, as has been mentioned, occurs native in abundance under the name of blende. It cannot easily be formed artificially. It is a tasteless, insoluble substance of a brown colour. It is about four times as heavy as water.

Cadmium, a new metal, discovered by Stromeyer.

Since this volume was prepared for the press, I find, by the scientific journals, that Stromeyer has discovered a new metal, to which he has given the name of *Cadmium*. The discovery was made in the autumn of 1817.

This metal owed its discovery to the following circumstances. Stromeyer, while making a general inspection of the apothecaries' shops, found, that, in several of them, a carbonate of zinc was sold under the name of the oxide. Upon inquiring the reason of this, at the manufactory where the preparation of zinc had been made; the explanation given was, that the carbonate, when exposed to heat for conversion into oxide, always assumed a yellow colour, seeming to indicate the presence of iron or lead, although neither of these metals could be detected in it. The result of the examination of this suspected oxide, by Stromeyer, was the discovery of cadmium, to which it owed its peculiar colour. Since making this discovery, Stromeyer has found the same metal in tutty, and several other oxides of zinc, but always in small amount, varying from 1 per cent. to $\frac{1}{10}$ of 1 per cent. He has, however, more lately discovered it in a preparation of zinc from Silesia, which had been supposed to contain arsenic. In this last, the new metal exists to the amount of three per cent.

Its properties.

Cadmium has a light white colour, inclining a little to grey. It possesses considerable brilliancy, and admits of a fine polish. It has a compact texture and hackly fracture.

Spec. grav. 8·750.

It is about eight and three-fourth times as heavy as water. It is ductile and malleable, when either cold or hot. Its melting point is somewhat under redness, and its point of

vaporization, under that at which mercury boils. It is precipitated from its solutions by zinc in the metallic state. It forms but one oxide, which may be obtained readily by combustion. This oxide has a greenish-yellow colour. It possesses all the properties of a salifiable base, and the salts, which it forms, have generally a white colour.* Chap. III.

Lampadius has lately discovered a new metal in a mineral from Hungary, supposed to have been a cobalt ore. He has given it the name of *Wodanium*. It occurs in the Hungarian mineral to the amount of 20 per cent. associated with sulphur, arsenic, iron and nickel. Wodanium, a newly discovered metal.

This new metal has a bronze yellow colour. It possesses malleability, and has a hackly fracture. It is not tarnished by mere exposure to air; but when heated, it is converted into a black oxide. It is about eleven and a half times as heavy as water.† Its properties. Spec. grav. 11·470.

SECTION VIII.

OF LEAD.

I. Lead may be obtained pure by the following process: Dissolve the lead of commerce in nitric acid, and precipitate the solution by means of sulphuric acid. Separate the precipitate thus formed; and, after being washed and dried, mix it with two or three times its weight of black flux, and expose it to a red heat.—When sulphuric acid is added to a nitric solution of impure lead, a pure sulphate of lead precipitates. The lead is obtained from this sulphate in consequence of the heat to which it is exposed, which drives off the sulphuric acid and oxygen. Lead; how obtained pure.

II. Lead is obtained, in the large way, by a very different process: The ore called galena (sulphuret of lead) is separated from impurities as far as possible, and then pulverized and washed. It is next roasted in a reverberatory furnace; taking care to stir it about, in order to expose all its surfaces to the air. When it begins to soften, it is to be mixed with charcoal, and the mixture stirred, while the heat is increased gradually. After some time the lead in the metallic state begins to run, and passes through holes in the bottom of the furnace into a recipient below. The metal is then cast in How obtained in the large way.

* Annals of Philosophy, (Feb. 1819) p. 108, et seq. † Ibid. (March 1819) p. 232.

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iron moulds, so as to form the oblong masses, known in commerce by the name of pig lead.

Lead occurs native usually as a sulphuret.

III. The most abundant ore of lead is galena (sulphuret of lead). The metal occurs also in the state of oxide, and in combination with acids.

Properties of lead.

IV. Lead has a bluish white colour, and, after being newly melted, a bright surface, which soon tarnishes. It has a perceptible taste, and a peculiar smell upon friction. It is very soft and malleable; but its ductility is not very great. Its fusing point is at the temperature of 612°; and when subjected to a greater heat, in close vessels, it boils and rises in the form of vapour.

Spec. grav. 11·352.

V. It is somewhat less than eleven and a half times as heavy as water.

Lead forms with oxygen, 1. Protoxide. 2. Litharge. 3. Peroxide. 4. Red oxide. Vitrified oxides of lead used in cupellation.

VI. Lead combines in two proportions with oxygen, and forms protoxide and peroxide of lead. Litharge is an impure protoxide of lead, and will be described immediately after the protoxide. Red lead is a mixture of the two oxides of lead, and will be noticed after the peroxide. All these oxides, when vitrified by fusion, are found very useful in purifying silver and gold. When in fusion, they have the property of oxidizing, and combining with, all the inferior metals. Hence, if impure silver or gold be melted with a portion of lead, in a shallow cup called a *cupel*, made of ashes and burnt bones, and the heat continued for some time; the lead becomes oxidized, and, after vitrification, combines with the contaminating metals and sinks into the cupel; while the silver or gold remains behind in a pure state. This process, from the name of the cup employed, is called *cupellation*.—The oxides of lead will now be considered individually.

I. *Protoxide of Lead or Massicot.*

Protoxide of lead; its preparation.

1. This oxide may be obtained by dissolving lead in nitric acid, so as to form a colourless solution, and precipitating it by means of carbonate of potash, added in excess. The precipitate, after being washed and dried, and exposed to a red heat, consists of the oxide in question.

Properties.

2. Protoxide of lead is of a yellow colour. It has no taste; and is insoluble in water, but dissolves in acids and in potash. When exposed to a gentle heat, it melts into a yellow semi-transparent brittle glass.

Composition.

3. It is composed of

Lead	104
Oxygen	8
	112

4. The massicot of commerce appears to be this oxide; but it is prepared in a different manner from that just described. Lead is kept melted, and the pellicles which form on its surface are successively removed, until at last, the whole of the metal has undergone this conversion. The substance thus formed is next exposed, in an open vessel, to heat, and stirred, until it assume a yellow colour: by this management it becomes converted into massicot. The pellicles, when first obtained, are a mixture of metallic lead and protoxide. By the subsequent exposure to heat and stirring in an open vessel, the metallic portion absorbs oxygen, whereby the whole is converted into protoxide.

Massicot, a protoxide of lead its preparation.

II. *Semi-vitrified oxide of Lead, or Litharge.*

1. Semi-vitrified oxide of lead is formed during the process for separating from lead, a portion of silver, with which, in larger or smaller amount, the metal is usually combined. The process consists in this: The lead is placed upon a large flat dish called a test.* The flame of a blast furnace is made to act upon its surface; the effect of which is to convert the lead into a semi-vitrified substance; part of which is blown off the test, while the remainder sinks into it. Whatever portion of silver the lead may have contained, remains unaltered on the test. The semi-vitrified substance is this oxide of lead, commonly called *litharge*.

2. Litharge; its preparation.

2. Semi-vitrified oxide of lead appears to be composed of scales, partly of a red, and partly of a golden-yellow colour. It is found to consist of protoxide of lead, combined with a small portion of carbonic acid.

Consists of protoxide, combined with carbonic acid.

3. Semi-vitrified oxide of lead or litharge has several uses in the arts. It is employed in the glazing of pottery; and by painters to render linseed oil more drying. It enters as a component part in some kinds of glass; in the manufacture of which, it is useful by facilitating fusion.

Uses of litharge in the arts;

4. It is also very useful in pharmacy. It constitutes the bases of a number of plasters, which unquestionably are useful in abating inflammation, and as drying applications.

and in pharmacy.

III. *Peroxide of Lead.*

1. This oxide may be prepared by causing chlorine gas to pass into a vessel, partly filled with water, and containing red lead. The red lead becomes further oxidized at the expense of the water, and is at last dissolved. By dropping

3. Peroxide of lead; preparation.

* This instrument is formed by beating a mixture of burnt bones and fern ashes in an iron hoop so as to form a shallow cavity.

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potash into the solution thus obtained, a precipitate appears which consists of this oxide.

Its properties. 2. Peroxide of lead is a very fine light tasteless powder of a flea-brown colour. It is not acted upon by sulphuric or nitric acid. It decomposes hydrochloric (muriatic) acid, its hydrogen being absorbed, while its chlorine is evolved. When heated, it gives out half its oxygen and is converted into protoxide.

Composition. 3. It is composed of

Lead	104
Oxygen	16
	120.

—So that it appears that this oxide contains twice as much oxygen as the protoxide.

IV. *Red oxide of Lead, Minium, or Red Lead.*

4. Red oxide of lead; preparation. 1. Red oxide of lead may be obtained by the following process: Expose massicot, ground to fine powder, for forty-eight hours to heat, and let the flame of a furnace act upon its surface, while it is constantly stirred. The massicot absorbs oxygen and is converted into red oxide of lead.

Properties. 2. Red oxide of lead is a very heavy powder of an intensely red colour. It has no taste. When heated to redness, it gives out oxygen, and gradually melts into a dark brown coloured glass.

Red lead of commerce, an impure red oxide. 3. The red lead of commerce is found to contain, besides red oxide of lead, some protoxide, together with sulphate and hydrochlorate (muriate) of lead, and silica. When separated from these substances, it was found to be composed of

Lead	208
Oxygen	24
	232.

—Hence it would appear that red oxide of lead is an intermediate oxide, containing three times as much oxygen, united to twice as much lead, as the protoxide. But the results obtained by the action of acids upon this oxide, favour the supposition that it is a compound of protoxide and peroxide, rather than a peculiar oxide. Thus if nitric acid be poured upon the red oxide of lead, a portion only is dissolved, which proves to consist of protoxide: the other portion, not attacked by the acid, is found to be peroxide. Now this separation into protoxide and peroxide always takes place, when the attempt is made to dissolve red oxide of lead in acids.

The red oxide, compounded of the protoxide and peroxide.

Uses of the red oxide. 4. Red oxide of lead as a paint is extensively used in the arts. Of all the oxides of lead, it is preferred as a flux in the manufacture of glass.

VII. Lead combines in one proportion with chlorine and forms chloride of lead.

Lead forms one chloride.

1. Chloride of lead (horn lead) may be formed by precipitating a solution of nitrate of lead by chloride of sodium (common salt). The precipitate obtained, by being melted, is converted into this chloride.

Its properties.

2. Chloride of lead is a semi-transparent substance of a greyish-white colour, having some resemblance to horn. When heated in the open air, it evaporates in the form of a white smoke; but in close vessels, it remains fixed even at a red heat.

3. It is composed of

Lead	104
Chlorine	36
	140

Iodide of lead.

VIII. Lead is capable of forming an iodide by means of heat. It has a fine yellow colour. Its exact composition is not known.

Phosphuret.

IX. Phosphuret of lead may be formed by dropping bits of phosphorus into melted lead. It has a silver-white colour, with a shade of blue.

Sulphuret of lead, or galena.

X. Lead combines with sulphur and forms sulphuret of lead. It occurs abundantly native under the name of galena. It may, however, be formed artifically, by dropping sulphur into melted lead. It is a brittle, brilliant substance of a deep blue colour. It is much less fusible than lead. It is composed of

Lead	104
Sulphur	16
	120

Alloy of lead and antimony.

XI. The only important alloy which lead forms with the metals already described is that with antimony. When it contains about sixteen parts of lead united with one of antimony, it constitutes the metallic compound, of which printers' types are made.

Lead, a poison.

XII. The preparations of lead, when taken into the stomach, prove poisonous.

SECTION IX.

OF TIN.

Tin; how obtained pure.

I. Tin may be obtained pure, by boiling the tin of commerce, in nitric acid, for some time, and heating strongly

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the white powder thereby formed, in contact with about one-fourth of its weight of charcoal powder, in a covered crucible for half an hour.

How obtained from its ores.

II. This metal is obtained from its ores, by fusion with powdered charcoal. The charcoal separates the oxygen of the ore; and the sulphur, when that is present, is driven off.

Ores of tin, where found.

III. The ores of tin are the sulphuret or tin pyrites, and two oxides, called tin stone and wood tin. In Europe, they are found abundantly in particular districts in Germany, Spain and England. They are found abundantly also in some parts of Asia. In South America they occur, but only in small amount.

Properties of tin.

IV. Tin has a fine white colour like silver, and considerable brilliancy, when free from tarnish. It has a slightly disagreeable taste, and a peculiar smell when rubbed. Its hardness is between that of gold and lead. It is very malleable, but does not possess much ductility. It is flexible and produces a crackling noise when bended. In air it loses its lustre, and becomes of a greyish black colour. Under water, at the common temperature of the atmosphere, it remains unaltered. Its melting point is at the temperature of 442°.

Spec. grav. 7·291.

V. Tin is nearly seven and one-third times as heavy as water.

Tin forms two oxides.

VI. Tin combines in two proportions with oxygen, and forms protoxide and peroxide of tin.

1. Protoxide.

1. *Protoxide of tin* may be obtained pure by adding potash, in excess, to a solution of tin, in hydrochloric (muriatic) acid, formed by the assistance of heat. A white powder falls, part of which is redissolved; what remains is protoxide of tin.

Its properties.

2. Protoxide of tin has a dark grey colour, and some metallic lustre. It has no taste. It is soluble in acids and in solutions of the principal salifiable bases. When heated it takes fire, undergoes combustion, and is converted into the peroxide. When in solution, the same conversion takes place by the absorption of oxygen.

3. It is composed of

Tin	59
Oxygen	8
	67

2. Peroxide.

1. *Peroxide of tin* may be formed by heating tin in strong nitric acid. A violent effervescence takes place, and the whole of the metal is converted into a white powder, which consists of this oxide. It may be obtained also by heating tin very violently in an open vessel. The metal catches fire, and the product of the combustion is this oxide.

2. Peroxide of tin, when pure, has a yellow colour; but very often it is obtained white, which is owing to the presence of water. It combines with both acids and salifiable bases. *Chap. III.* *Its properties.*

3. It is composed of

Tin	59
Oxygen	16
	75.—So that it contains

twice as much oxygen as the protoxide.

VII. Tin combines in two proportions with chlorine, and forms protochloride and perchloride of tin. *Tin forms two chlorides.*

1. *Protochloride of tin* may be obtained by evaporating, to dryness, the hydrochlorate (muriate) of tin, and fusing the dry mass in a close vessel. *1 Protochloride.*

2. It has a grey colour and the resinous lustre and fracture. When it comes in contact with water, this liquid is decomposed; and the chloride is changed into a hydrochlorate (muriate); when heated in chlorine gas, it undergoes combustion, and is converted into the perchloride. *Its properties.*

3. It is composed of

Tin	59
Chlorine	36
	95

1. *Perchloride of tin* (fuming liquor of Libavius.—Oxymuriate of tin) may be formed by distilling, at a moderate heat, a mixture of six parts of tin, one part of mercury, and thirty-three parts of perchloride of mercury (corrosive sublimate). At first a colourless liquid passes into the receiver; but afterwards there suddenly rushes in a white vapour, which condenses, in the receiver, into a fuming liquid: this liquid is perchloride of tin. This same chloride is obtained by the combustion of tin in chlorine gas. When introduced into it, the metal undergoes this process and the product is the chloride in question. *2. Perchloride.*

2. Perchloride of tin is a colourless liquid like water. When exposed to the air, it fumes violently, owing to the avidity with which it absorbs moisture. *Its properties.*

3. It is composed of

Tin	59
Chlorine	82*
	141.—So that this chlo-

ride contains considerably more than twice as much chlorine as the protochloride. The chlorides of tin do not admit of any exact comparison as to composition.

VIII. Iodide of tin may be formed by bringing the melt- *Iodide of tin.*

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ed metal in contact with the vapour of iodine. It is a very fusible substance of a dirty orange colour. When it comes in contact with water, it decomposes that liquid, and is converted into hydriodic acid and oxide of tin.

Phosphuret.

IX. Phosphuret of tin may be formed by dropping phosphorus into melted tin. It has the colour of silver, and its filings resemble those of lead. When thrown upon hot coals, the phosphorus, which it contains, catches fire. It is composed of

Tin	59
Phosphorus	10*
	69

Tin forms two sulphurets.

X. Tin combines in two proportions with sulphur, and forms sulphuret and bisulphuret of tin.

1. Sulphuret.

1. *Sulphuret of tin* may be obtained by fusing tin with sulphur, reducing the resulting mass to powder, and fusing it again, with another portion of sulphur; taking care to keep it at a temperature sufficiently high to drive off the superabundant sulphur.

Its properties.

2. This sulphuret has a lead colour, and the metallic lustre. When acted upon by hydrochloric (muriatic) acid, it is converted into oxide of tin and hydrosulphuric acid (sulphuretted hydrogen.)

3. It is composed of

Tin	59
Sulphur	16
	75

2. Bisulphuret.

1. *Bisulphuret of tin*, formerly called mosaic gold (aurum mosaicum) may be obtained by exposing a mixture of twelve parts of tin, seven parts of sulphur and three parts of hydrochlorate of ammonia (sal ammoniac) to a strong heat, for eight hours, in a black lead crucible, to which is luted a vessel to receive the sublimed product. This sulphuret will be found sublimed.

Its properties.

2. Bisulphuret of tin, when pure, consists of light scales of the colour of gold. When heated it lets go part of its sulphur, and is converted into the simple sulphuret. It is insoluble in water, and is not acted upon by hydrochloric (muriatic) or nitric acid.

3. It is composed of

Tin	59
Sulphur	32
	91.

—So that it is properly entitled to the name of bisulphuret; as it contains twice as much sulphur, as the simple sulphuret.

XI. The following are the only alloys of tin with the metals already described, that deserve to be mentioned. *Chap. III. Alloys of tin, with antimony;*

1. An alloy of tin and antimony constitutes the metallic plates upon which music is engraved.

2. Tin and iron are not very readily combined, so as to form an alloy; but the formation of tin plates affords sufficient proof that there is some affinity between them. Tin plate is made by dipping into melted tin, thin plates of iron, made thoroughly clean, first by rubbing them with sand, and afterwards by steeping them in water acidulated by bran or sulphuric acid. The tin gives a coating to the iron, which it renders uniformly white. *with iron;*

3. An alloy of tin and zinc constitutes the principal part of some species of pewter. *with zinc;*

4. Tin and lead, united in different proportions, constitute plumber's solder, as well as the more common kinds of pewter. Tin foil always contains a portion of lead. *and with lead.*

XII. Tin has many uses. The covering which it affords to iron and copper vessels, makes it of great importance to mankind. *Uses of tin.*

XIII. Tin, in a state of powder, is sometimes used in medicine. In large doses, it is considered very efficacious for expelling the tape worm. *Medical uses.*

SECTION X.

OF COPPER.

I. Copper may be obtained pure by the following process: Dissolve the copper of commerce in strong hydrochloric (muriatic) acid. Immerse into the solution thus formed, diluted with water, a polished piece of iron. The copper is precipitated in the metallic state. The precipitate, after being washed and dried, is pure copper. *Copper; how obtained pure.*

II. The copper of commerce may be obtained from its ores, by first pounding and washing them; and afterwards, if they contain sulphur, subjecting them to the operation of roasting for several successive times. They are then to be melted into a mass. After the copper is obtained, in a certain degree of purity, by these processes, it is fused hastily with three times its weight of lead. This latter metal dissipates, or separates in scoriæ, the sulphur, arsenic, iron, and other foreign substances, with which it may be contaminated. It is afterwards subjected to a second fusion, by which other impurities are made to rise to the surface, in the form of *How obtained from its ores in the large way.*

Book I. Division I. scoriæ. The purity of the metal is then tested by the immersion of a rod of iron into the melted mass: the iron becomes coated with copper, the quality of which may be readily ascertained upon examination.

How found native. III. Copper is found abundantly, in different parts of the world, in the states of sulphurets, oxides and salts.

Properties of copper. IV. Copper has a fine red colour, and a great deal of brilliancy. It possesses a nauseous and styptic taste, and a disagreeable smell when rubbed. It is very malleable, and possesses considerable ductility. Its hardness exceeds that of silver. It is not altered under water. Its fusing point is at 27° of Wedgewood; and when exposed to a greater heat, it evaporates in visible fumes. When subjected to a violent heat, such as is produced by the combustion of a mixture of oxygen and hydrogen gases, it takes fire and burns with great brilliancy, emitting a very intense green light.

Spec. grav. 8 895. V. It is very nearly nine times as heavy as water.

Copper forms two oxides. VI. Copper combines in two proportions with oxygen, and forms protoxide and peroxide of copper. Both these oxides enter into the composition of salts.

1. Protoxide. 1. *Protoxide of copper* may be obtained by putting pieces of rolled copper into a solution of copper in hydrochloric (muriatic) acid, contained in a phial, which must then be closely corked. After some time, the colour of the solution, which is at first green, becomes converted into a dark brown. Add, to the liquid as it now stands, a solution of potash. A precipitate immediately falls, which consists of protoxide of copper.

Its properties. 2. This oxide is red when native; but when formed artificially, it has a yellow colour. It is composed of

Copper	64
Oxygen	8
	72

2. Peroxide. 1. *Peroxide of copper* may be formed by keeping red hot for some time, in an open vessel, the scales which form on the surface of copper, when exposed to a red heat. By being thus treated, the scales absorb oxygen and are converted into the peroxide in question.

Its properties. 2. This oxide is a tasteless black powder, soluble in acids. It is composed of

Copper	64
Oxygen	16
	80

—So that it is obvious that this oxide of copper contains twice as much oxygen as the protoxide.

Copper forms two chlorides. VII. Copper combines in two proportions with chlorine, and forms protochloride and perchloride of copper.

1. *Protochloride of copper* may be formed by heating a mixture of two parts of perchloride of mercury (corrosive sublimate) and one part of copper. The chlorine separates from the mercury, and combines with the copper, so as to form this chloride.

CHAP. III. 1. Protochloride.

2. This chloride has an amber colour, and a certain degree of transparency. In close vessels it is not decomposed at a red heat; but at the same temperature in the open air, it dissipates in white fumes. It is composed of

Its properties.

Copper	64
Chlorine	36
	100

1. *Perchloride of copper* may be formed by evaporating perhydrochlorate (green muriate) of copper to dryness, at a heat not exceeding 400°. The hydrogen of the acid, and the oxygen of the oxide of copper are driven off, and what remains consists of this chloride.

2. Perchloride.

2. Perchloride of copper has a brownish yellow colour. When exposed to the air, it absorbs moisture, and becomes, first white and then of a green colour. Heat drives off part of its chlorine, and converts it into the protochloride. It is composed of

Its properties.

Copper	64
Chlorine	72
	136.

—So that it is obvious that this chloride of copper contains twice as much chlorine as the protochloride.

VIII. Iodide of copper may be formed by heating its constituents together. It has been but very slightly examined. Its composition is not known.

Iodide of copper.

IX. Phosphuret of copper may be formed by throwing pieces of phosphorus upon red hot copper. This phosphuret is neither ductile nor pulverizable. It is harder than iron, and much more fusible than copper. When exposed to the air, it loses its lustre, and falls to pieces; the copper being oxidized, and the phosphorus converted into phosphoric acid.

Phosphuret.

X. Sulphuret of copper may be formed, by exposing, in a glass receiver, a mixture of eight parts of copper filings, and three parts of flowers of sulphur, to the heat of burning coals. The mass first melts, and then explodes gently; after which, when the combination is complete, it becomes red hot. It is a brittle substance, of a deep blue-grey colour. It is much more fusible than copper. It is composed of

Sulphuret.

Copper	64
Sulphur	16
	80

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XI. The following alloys of copper, with metals already described, deserve to be mentioned.

Alloys of copper, with iron;

1. The variety of iron, which is brittle when red hot, and from this circumstance called *hot short*, is supposed to derive its peculiar qualities from the presence of copper.

with zinc; and

2. The alloy of copper and zinc constitutes different kinds of brass. It is formed, by the manufacturer, by melting together, granulated copper, the native ore called calamine, and a proportion of charcoal powder. The fusion must be kept up for five or six hours. By this mode of proceeding, the zinc of the calamine becomes deoxidized, and combines with the copper. The most intimate compound of these metals is in the proportion of 64 parts of copper, to 33 parts of zinc.

Brass is much more fusible than copper. It is malleable when cold, if not containing too large a proportion of zinc; but brittle when heated. It possesses ductility, and may be drawn out into very fine wire.

An alloy of copper and zinc, in which the zinc predominates in a certain degree, constitutes pinchbeck, or prince Rupert's metal.

with tin.

3. The alloy of copper and tin, united in different proportions, constitutes the metals of which bells, bronze, cannons and the mirrors of telescopes are made. The tin in these alloys diminishes the ductility of the copper, but increases its hardness, fusibility and sonorousness. Bronze and the metal of which cannons are made, are composed of from eight to twelve parts of tin, combined with one hundred parts of copper. Bell metal contains about one-fourth of its weight of tin. The alloy for the mirrors of telescopes is composed of two parts of copper united to one part of tin.

Process of tinning copper described.

4. In consequence of the ease, with which copper may be alloyed with tin; the former may be, very readily, covered with a coating of the latter. A coating of tin is very frequently given to copper vessels, intended for use in cooking, to guard against the bad effects of the copper. The process of tinning copper is conducted in the following manner. The vessel to be tinned has its interior surface scraped very clean with an iron instrument, and then rubbed with hydrochlorate of ammonia (sal ammoniac). It is then heated, and a little pitch thrown into it, which is allowed to spread. While in this state of preparation, the tin is rubbed over the whole surface, which immediately assumes a silvery white colour. The previous steps in the process are necessary to render the copper perfectly clean; for the tin will not adhere, if the surface of the copper be in the least degree tarnished.

Most generally it is not tin, but an alloy of tin and lead, which is used to give this coating to copper vessels. It was supposed probable, therefore, that the latter metal might be dissolved, when such vessels were used for preparing food, more particularly acid food. Experiments have been made to ascertain this point; and it appears that the presence of the tin prevents altogether any solution of the lead. Accordingly copper vessels, tinned with this alloy, may be employed for the preparation of food without hazard. Chap. III.

Metallic copper, not used in medicine.

XII. Metallic copper is not employed in medicine. But in different states of combination, it furnishes the physician with several valuable preparations. These will be noticed hereafter under distinct heads.

SECTION XI.

OF BISMUTH.

Bismuth; how obtained pure.

I. Bismuth may be obtained by the following process: Dissolve the bismuth of commerce in strong nitric acid, and precipitate the solution by adding water. Wash the precipitate, which consists of oxide of bismuth; and after being dried, expose it for twenty minutes to a dull red heat, mixed with black flux. The precipitate becomes deoxidized, and a button of pure bismuth is obtained.

How obtained from its ores.

II. Bismuth is usually obtained from its ores, by fusion with one-eighth of their weight of white flux. The sulphur and oxygen, which may be present, are separated, and the pure bismuth remains behind.

Where found.

III. Bismuth has been found in Sweden, France and England; but it occurs in by far greater abundance in Saxony than in any other country. It exists usually in the state of sulphuret or of oxide.

Properties of bismuth.

IV. Bismuth has a white colour with a tint of red. It is tasteless and inodorous. In texture, it is composed of brilliant plates, adhering to each other. When exposed to the air, it suffers a slight tarnish, but remains unaltered under water. It is neither malleable nor ductile. In hardness it is inferior to copper. Its fusing point is at the temperature of 476°; and if the heat be increased beyond this degree in close vessels, the metal may be distilled over.

Spec. grav. 9·822.

V. It is somewhat less than ten times as heavy as water.

Bismuth forms but one oxide;

VI. Bismuth combines with oxygen in one proportion only, and forms oxide of bismuth.

1. This oxide may be formed by keeping bismuth in a state of fusion, exposed to the open air. A pellicle forms on

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the surface of the metal, which is quickly succeeded by another, as soon as the first is removed. By continuing the fusion, the whole metal may at last be converted into these pellicles. They are then to be heated, with agitation, for some time in an open vessel; by which treatment they absorb oxygen and are converted into the oxide in question. Oxide of bismuth may be formed also by combustion. When bismuth is exposed to a strong red heat, it catches fire, and burns with a faint blue flame; the product being this oxide.

2. Oxide of bismuth is a tasteless insoluble yellow powder. It is composed of

Bismuth	71
Oxide	8
	79

and but one chloride.

VII. Bismuth combines in one proportion with chlorine, and forms chloride of bismuth.

1. Chloride of bismuth, formerly called butter of bismuth, may be obtained by keeping in a state of fusion for several hours, a mixture of perchloride of mercury (corrosive sublimate) and bismuth. The chlorine is transferred from the mercury to the bismuth, with which it forms the chloride in question. The mercury, in the metallic state, sinks to the bottom of the vessel.

2. This chloride is opaque, of a greyish yellow colour, and granulated texture. In close vessels it does not sublime, even at a red heat. It is composed of

Bismuth	71
Chlorine	36
	107

Iodide of bismuth.

VIII. Iodide of bismuth may be formed by heating its constituents together. When thus formed, it is an insoluble substance, of an orange yellow colour. It has not been analyzed.

Sulphuret.

IX. Sulphuret of bismuth may be formed by fusing together its constituents. It is a very brittle and fusible substance, of a bluish grey colour. It is composed of

Bismuth	71
Sulphur	16
	87

SECTION XII.

OF MERCURY.

Common name, *Quicksilver*.

Mercury: how obtained pure.

I. Mercury may be obtained pure, by exposing, to an obscure red heat, a mixture of two parts of native sulphuret

of mercury (cinnabar) and one part of iron, contained in a stoneware retort, furnished with a receiver filled with water. The sulphur combines with the iron, and the mercury appears in the metallic state. Chap. III.

II. Mercury, either native or mineralized, has been found in Spain, Germany, and Hungary; in China and in Peru. The most productive mines are those of Idria, and of Almaden, near Cordova, in Spain. It occurs, forming an amalgam with silver; as a sulphuret (cinnabar), and as a chloride (horn mercury). Where found.

III. Mercury has a white colour, resembling that of silver, and possesses considerable brilliancy. It is liquid at the common temperature of the atmosphere; in which respect it differs from all other metals. It solidifies at the temperature of 39° below zero, of Fahrenheit's scale, and becomes much heavier. Its boiling point is at the temperature of 656°: accordingly it may be subjected to distillation, whereby it may be freed from admixture of contaminating metals. It is not altered by being kept under water, and suffers a slight tarnish only by exposure to the air. Properties of mercury.

IV. It is somewhat more than thirteen and a half times as heavy as water. Spec. grav. 13 568.

V. Mercury combines in two proportions with oxygen, and forms protoxide and peroxide of mercury. Mercury forms two oxides.

PROTOXIDE OF MERCURY. 1. Protoxide.

Formerly called, *Ethiops per se.*

1. This oxide may be formed by digesting protochloride of mercury (calomel) in a solution of potash. A powder is thereby formed, which consists of the oxide in question. It may be formed also by subjecting mercury, contained in a phial, to constant agitation. It was obtained in this way by the earlier chemists; and, from the manner of the process, was called *ethiops per se.* How prepared.

2. Protoxide of mercury is an insoluble powder of a black colour and coppery taste. It is destitute of metallic lustre. It is composed of

Mercury	200
Oxygen	8
	208

3. Mercury becomes slowly converted into protoxide by contact with the atmosphere. When minutely divided, by mechanical means, this conversion takes place much sooner; in consequence of the great increase of surface exposed to the influence of the air. Accordingly, whenever this metal is triturated with powders or viscid substances, it is converted into protoxide, which combines with the substance Formed also by trituration with certain substances.

Several medicinal preparations thus obtained.

employed. By taking advantage of this circumstance, several important preparations of mercury are made. When the metal is triturated with carbonate of lime (chalk), until its metallic nature disappear it forms a preparation of the London college, under the name of *quicksilver with chalk*. In very nearly the same manner, the officinal preparation of the Dublin college, called *quicksilver with magnesia*, is prepared. When triturated with conserve of roses, and afterwards mixed with some powder, such as of liquorice or of starch, to give the mass a proper consistence, it constitutes the preparation of which the officinal mercurial pills are formed. Mercurial ointment, the most common preparation of mercury for external use, consists of this oxide, formed, and combined, by trituration with lard.

2. Peroxide.

PEROXIDE OF MERCURY.

Common name, *Red Precipitate of Mercury*.

How obtained.

1. This oxide may be obtained by dissolving mercury in nitric acid, evaporating the solution to dryness, and exposing the dry mass to a heat gradually increased, until it become converted into very red scales. These scales consist of the oxide in question.

Preparation for use in medicine.

2. The Edinburgh college directs, for the preparation of this oxide, four parts of purified mercury to be dissolved in three parts of diluted nitrous acid. The solution thus formed is to be evaporated to dryness, and the mass obtained ground to powder. This powder is to be exposed, in a sand bath, to a gradually increased heat; until the whole is converted into very red scales. In both these processes the metal is peroxidized at the expense of the acid, which is partially decomposed.

Another method.

3. This oxide may be prepared also by exposing mercury, contained in a glass vessel, with a large bottom and a narrow mouth, to a greater heat than 656°, or the boiling point of mercury. The metal is converted into vapour, and, in that state, is oxidized by the atmospheric air, and condensed. By a continuance of the heat, for several months, the mercury is ultimately converted into a red powder, which consists of the oxide in question. When the peroxide is prepared in this manner, it is called *calcined quicksilver* by the London and Dublin colleges. It possesses, however, no superiority over that obtained by the action of nitric acid, when carefully prepared. The peroxide obtained by the method of the Edinburgh college is called the *red oxide of quicksilver by nitric acid*.

Peroxide described.

4. Peroxide of mercury, or red precipitate, has a bright scarlet colour, and an acrid and disagreeable taste. It is somewhat soluble in water.

5. It is composed of

Mercury	200
Oxygen	16
	216

—so that it appears, that this oxide contains twice as much oxygen as the protoxide.

6. Peroxide of mercury is a very useful preparation in medicine. It operates as a poison in the stomach, and possesses the properties of an active caustic when applied to the skin. When mixed with a mild ointment, it forms one of the best applications for indolent and other ill-conditioned ulcers. Its medical uses.

VI. Mercury combines in two proportions with chlorine, and forms protochloride and perchloride of mercury. Mercury forms two chlorides.

PROTOCHLORIDE OF MERCURY.

Usual chemical names, *Mild Muriate of Mercury—Sub-Muriate of Mercury.* Common name, *Calomel.* 1. Protochloride, or calomel.

1. Protochloride of mercury or calomel may be prepared by the following process: Dissolve in boiling nitric acid as much mercury as this solvent can take up. Make a solution of chloride of sodium (common salt), containing half as much of this chloride, as the nitric solution does of mercury. Into the solution thus formed, pour cautiously the boiling nitric solution of the mercury. This addition causes a white precipitate to fall, which must be washed until the water employed comes off tasteless, and then dried on a filter. This precipitate consists of the chloride under consideration. It is formed in this process in consequence of a double decomposition. No sooner is the nitric solution of the mercury added to the solution of the chloride of sodium, than the mercury, being previously deoxidized, falls in combination with the chlorine of the chloride, in such a proportion as to constitute the protochloride of mercury. The sodium of the common salt becomes oxidized, and combines with the nitric acid; so that, after the precipitated chloride is removed, the remaining liquid is a solution of nitrate of soda. How obtained.

2. The Edinburgh college directs the following process for preparing this chloride: Rub together in a glass mortar, with a little water, four parts of pulverized perchloride of mercury (corrosive sublimate) and three parts of pure mercury, until all the metal is extinguished. Sublime the powder thus formed, after being dried, in an oblong phial only one-third filled, by the heat of warm sand. When the sublimation is finished, break the phial, and separate the red matter found near its bottom, and the white matter near its neck. Sublime the remainder a second time, grind it into a very fine powder, and wash it with boiling distilled Preparation for medical use.

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water. It is now pure protochloride of mercury or calomel.

This last process explained.

3. In the above process of the Edinburgh college, the trituration of the perchloride of mercury (corrosive sublimate) with pure mercury, has the effect of decomposing the former, and enabling its chlorine to combine with the metallic mercury, as an additional quantity. What, therefore, was at first a perchloride becomes, in this way, converted into a protochloride. This conversion, however, is not entirely complete; and hence the necessity of sublimation. But even after this measure is taken, there still exists, in the upper and lower parts of the vessel, in which the sublimation is performed, portions of perchloride not completely converted into the protochloride. These, therefore, are directed by the Edinburgh college, to be separated from the middle portion, which is again sublimed as a measure of farther precaution. The other colleges, however, triturate in a mortar, the entire product of the first sublimation, so as to mix its several parts; and sublime it again, the Dublin college once, and the London college four times. The mode of proceeding of these colleges must be considered as equally good, in result, with that pursued by the Edinburgh college; and it has the advantage of economizing the ingredients. It is very probable that one sublimation, as pursued by the Dublin college, may be sufficient. At any rate, no unpleasant consequences would arise from the use of calomel, prepared in this way, if it be carefully washed; since, in this process, all adhering perchloride (corrosive sublimate), from its greater solubility, would be abstracted.

Properties of the protochloride.

4. Protochloride of mercury, or calomel, is an insoluble powder of a dull white colour, and possessing very little taste. It is somewhat more than seven times as heavy as water. When acted upon by chlorine gas, it is converted into perchloride of mercury (corrosive sublimate.)

5. It is composed of

Mercury	200
Chlorine	36
	236

This chloride, a very important medicine.

6. It would require volumes to recount the many valuable applications of this chloride. It is suited to almost every case, in which the internal employment of mercury is indicated. It acts as a gentle purgative in most cases; but its most remarkable property is that of stimulating the secretory organs, more particularly the liver. It is the preparation of mercury most usually given to produce a salivation. In the venereal disease, except in peculiar cases, no form of mercury can be substituted for it with advantage.

PERCHLORIDE OF MERCURY.

Usual Chem. names, *Corrosive Muriate of Mercury.—Oxymuriate of Mercury.*
Common name, *Corrosive Sublimate.*

2. Perchloride, or corrosive sublimate; how obtained.

1. This chloride may be obtained by dissolving peroxide of mercury in hydrochloric (muriatic) acid. The hydrogen of the acid, and the oxygen of the oxide combine and form water; while the chlorine of the former, and the mercury of the latter unite to form the chloride.

Preparation for medical use.

2. The British colleges, for the formation of this chloride, direct the following process: Take of purified mercury, four parts; sulphuric acid, five parts, and dried chloride of sodium (common salt) eight parts. Boil the mercury in the sulphuric acid, contained in a glass vessel, until the mass become dry; and then mix it, when cold, with the chloride of sodium. Sublime the mixture, in a glass vessel, with a heat gradually increased. The sublimed product is perchloride of mercury.

Last process explained.

3. In the process just given, the mercury, by being boiled with the sulphuric acid, becomes oxidized at the expense of part of the acid; while, with the remainder, it forms the compound called sub-sulphate of mercury. When the sub-sulphate is sublimed in a state of mixture with dry chloride of sodium (common salt), a double decomposition takes place; the chlorine of the chloride combines with the mercury of the sub-sulphate, and this compound sublimes; while the sulphuric acid unites with the sodium, previously converted to the state of soda, by the oxygen, which had been displaced from combination with the mercury. The residue of the sublimation is, therefore, a sulphate of soda (glauber salt.)

Its properties.

4. Perchloride of mercury, or corrosive sublimate, when obtained by sublimation, is a beautiful white semi-transparent substance. It has an excessively acrid and caustic taste; and leaves, for a long time, a disagreeable, metallic, styptic impression in the mouth. It is soluble in about twenty times its weight of cold water, and in twice its weight of boiling water. It is soluble in sulphuric, nitric or hydrochloric (muriatic) acid; and may be obtained, from solution in either, by evaporation unaltered. It is decomposed by solutions of potash or of soda, which throw down the mercury in the state of peroxide, of a yellow colour, becoming afterwards brick-red.

Forms a precipitate with ammonia.

5. When ammonia is added to a solution of perchloride of mercury (corrosive sublimate), a white precipitate falls, consisting of the perchloride, combined with a small proportion of ammonia. This compound is usually called by chemists, a *suboxymuriate of mercury-and-ammonia;* it is

Book I. Division I. the *white calx of quicksilver* of the London college, and is employed medicinally only in the form of ointment. If named in conformity with the improved nomenclature, it ought, perhaps, to be called the *ammoniated perchloride of mercury*.

6. Perchloride of mercury is composed of

Mercury	200
Chlorine	72
	272.

—So that it is evident that this chloride contains twice as much chlorine as the protochloride.

Its medical uses. 7. Perchloride of mercury or corrosive sublimate is so very active a substance, as to be properly classed among poisons. Nevertheless it may be employed internally, in small doses, for the cure of diseases. It has been given for the cure of the venereal disease; but it does not deserve the same confidence as the protochloride (calomel); neither is it so innocent or manageable. As an external application, it is useful in solution, to destroy fungous flesh, to cleanse ulcers and to cure herpetic eruptions; but the strength of the solution must be carefully attended to. A large portion of ulcerated surface cannot be washed with it without danger. The solution is very useful also in ulcerations of the throat, and in promoting the desquamation of eruptions.

Poisoning by this chloride described. 8. When this chloride is taken, whether by accident or design, in too large quantities, it occasions very dreadful consequences. It causes a burning heat and sense of stricture in the throat; excruciating pain in the stomach; nausea and vomiting, attended by violent efforts.* It has been ascertained by late experiments, that the most effectual antidote to this poison is albumen or white of the egg. This latter substance, given in large quantities, beat up with water, combines with the poison, with the effect of rendering it nearly inert.†

Mercury forms two iodides. VII. Mercury combines in two proportions with iodine. The protiodide has a yellow colour, and the periodide, a beautiful red. They are both soluble in water.

Phosphuret of mercury. VIII. Phosphuret of mercury may be formed by distilling a mixture of peroxide of mercury with phosphorus. The oxide parts with its oxygen, which acidifies a portion of the phosphorus; and after being thus reduced to the metallic state, combines with the remainder of this combustible, to form the phosphuret in question. It has a black colour and a pretty solid consistence. When exposed to the air it exhales vapours of phosphorus.

* See Nancrede's edition of Orfila on Poisons, p. 26. † Ibid. p. 39, et seq.

IX. Mercury combines in two proportions with sulphur, and forms sulphuret and bisulphuret of mercury. Chap. III. Mercury forms two sulphurets.

SULPHURET OF MERCURY.

Common name, *Ethiops Mineral.*

1. This sulphuret may be formed by adding mercury, slowly, to its own weight of melted sulphur; stirring at the same time the mixture constantly, until the union be complete. It may be formed also by passing a current of hydrosulphuric acid (sulphuretted hydrogen) through a solution of mercury in an acid. The precipitate which will appear is the sulphuret in question. 1. Sulphuret; how prepared.

2. Sulphuret of mercury is a black powder, which remains unaltered in the air. When exposed to heat, it emits sulphureous fumes. It is insoluble in nitric acid, but dissolves in a solution of potash; from which it may be precipitated unchanged by acids. It is composed of Described.

Mercury	200
Sulphur	16
	216

3. This sulphuret has been used in medicine, as an alterative, in glandular and cutaneous diseases. But, without doubt, no effects can be expected from its use, which are not more certainly produced by other preparations of mercury. Its medical uses.

BISULPHURET OF MERCURY.

Common names, *Cinnabar.—Vermilion.*

1. Bisulphuret of mercury may be obtained by subliming the simple sulphuret at a red heat. The sublimed product constitutes this sulphuret. 2. Bisulphuret.

2. It is a tasteless insoluble substance of a fine scarlet colour. It is not altered by exposure to air. When heated it takes fire and burns with a blue flame. When in the form of a very fine powder, it is known in commerce by the name of vermilion. It is composed of Properties.

Mercury	200
Sulphur	32
	232.—Accordingly it con-

tains twice as much sulphur as the simple sulphuret.

3. Bisulphuret of mercury was formerly much more employed in medicine than at present. It is sometimes used in fumigations for venereal ulcers of the nose and throat; and most usually produces a very prompt ptyalism. Used in medicine.

X. Mercury combines with most of the metals. These combinations are called amalgams. Only two of them will be mentioned. Amalgam

of zinc: 1. The amalgam of zinc, composed of two parts of zinc, and five parts of mercury, is found useful for promoting the excitement of electrical machines.

of tin. 2. The amalgam of tin is used for silvering the backs of looking glasses. The process is as follows: tin foil is spread upon a marble table, and mercury poured upon it, and incorporated with a brush. The plate of glass, to be silvered, is then slid over the amalgam, so as to prevent the presence of air between it and the metal; and pressed down by weights. The superfluous mercury is thereby pressed out from under the plate; and by continuing the pressure for a certain length of time, a thin layer of the tin amalgam adheres to the surface of the glass.

Mercury, important in the materia medica. XI. From what has already been said of some of its compounds, it is very evident that mercury constitutes one of the most important articles of the materia medica. In the progress of the work, however, several other important preparations of this metal will be noticed.

SECTION XIII.

OF SILVER.

Silver; how obtained pure. I. Silver may be obtained pure by the following process: Dissolve the silver of commerce in nitric acid, and precipitate the solution by chloride of sodium (common salt). Ignite the precipitate, after being washed and dried, with three times its weight of carbonate of potash (salt of tartar), mixed with a little charcoal powder. A button of pure silver will be obtained.

How found. II. This metal is found in the state of alloy, with gold, antimony, arsenic and bismuth; as a sulphuret; in the form of oxide, called red silver ore; in the form of a chloride (horn silver); and combined with carbonic acid. It occurs in Bohemia, Norway and Transylvania. But by far the most productive mines of silver are those of South America.

How extracted from its ores. III. The most usual method of extracting silver is the following: The ore is first pounded, then roasted and washed, and afterwards triturated with mercury under water. An amalgam of silver becomes in this way formed, which is washed and strained through leather. It is then subjected to distillation; whereby the mercury is driven off and the silver left pure.

Properties of silver. IV. Silver has a white colour with a tint of yellow. It has no taste or smell. It possesses a good deal of brilliancy. Its hardness is intermediate between that of copper and gold.

It is remarkably malleable and ductile. In the air it suffers a tarnish, which is ascertained to be produced by sulphur. Its melting point is at 22° of Wedgewood. When subjected to the heat produced by the combustion of a stream of oxygen and hydrogen gases, it burns rapidly with a light blue flame.

V. Silver is about ten and a half times as heavy as water. Spec. grav. 10·474.

VI. Silver combines with oxygen in one proportion only, and forms oxide of silver. Silver forms but one oxide;

1. It may be obtained by dissolving silver in nitric acid, and precipitating the solution by lime water. The precipitate obtained consists of this oxide.

2. Oxide of silver is a tasteless insoluble powder of a dark olive brown colour. It dissolves readily in nitric acid. When heated to redness, it is deoxidized and reduced to the metallic state. It is composed of

Silver	110
Oxygen	8
	118

VII. Silver combines with chlorine and forms chloride of silver. and but one chloride.

1. Chloride of silver (muriate of silver), formerly called *horn silver*, may be obtained by dissolving silver in nitric acid, and adding the solution thus formed to a solution of chloride of sodium (common salt). A precipitate appears which consists of this chloride. After it is separated, what remains is a solution of nitrate of soda.

2. Chloride of silver is a white substance, very insoluble in water. When exposed to the air, it acquires a purple colour. At a heat of 500° it melts; and upon cooling, assumes the form of a grey semi-transparent mass, having some resemblance to horn. It is soluble in ammonia and in hydrochloric (muriatic) acid. Both potash and soda in the state of carbonates produce its decomposition; but in the pure state, have no effect upon it. None of the acids are capable of effecting its decomposition. When dissolved in ammonia, and mixed with running mercury, the silver gradually combines with the latter, and crystallizes into that beautiful appearance, called Arbor Dianæ or Diana's tree. The ammoniacal solution of this chloride when heated, deposites a powder, which is oxide of silver combined with ammonia. This powder has the property of detonating when struck, and is hence called fulminating silver. Properties of the chloride.

3. Chloride of silver is composed of

Silver	110
Chlorine	36
	146

Iodide of silver.

VIII. Iodide of silver may be obtained by dropping an hydriodate into a solution of nitrate of silver. The hydriodic acid is decomposed; its iodine combines with the silver, so as to form the iodide in question; while its hydrogen combining with the oxygen of the oxide of silver, forms water. It is an insoluble substance of a greenish-yellow colour, having considerable resemblance to chloride of silver.

Phosphuret.

IX. Phosphuret of silver may be formed by melting together equal parts of silver and phosphoric acid, along with one-eighth of their weight of charcoal. The phosphoric acid parts with its oxygen to the charcoal; and thus reduced to phosphorus, combines with the silver. It is a solid substance of a white colour and granular texture. It is decomposed by heat; the phosphorus exhaling in fumes.

Sulphuret.

X. Sulphuret of silver may be formed by melting together thin plates of silver and sulphur, laid alternately in a crucible. It occurs native of a deep violet colour. It is much more fusible than silver. It is composed of

Silver	110
Sulphur	16
	126

Alloy of silver with copper, forms silver coin.

XI. The only alloy of silver with metals already described, which will be noticed, is that with copper. This alloy is harder and more sonorous than silver. It is white, and retains that colour, even when the proportion of copper exceeds one half. Its hardness is greatest, when it contains about one eighth of its weight of copper. Silver coin consists of this alloy. The proportion of copper directed by different nations to make their silver standard is various. The following table gives the proportion of pure silver, combined with one part of copper, in the silver coin of several countries.

COINS.	Parts of pure silver, combined with one of copper.
Silver coin of the United States,	8·3
Britain,	12·3
France,	9·
Spain,	8·7

SECTION XIV.

OF GOLD.

Gold; how obtained pure.

I. Gold may be obtained pure by the following process: Treat native gold with aqua regia, until every thing soluble be taken up. If any silver had been present, it remains behind

in the form of an insoluble chloride (horn silver). Separate the clear solution from this residue, and add to it a solution of sulphate of iron, (green vitriol): a precipitate falls, which consists of pure gold. After being separated and washed, it may be fused into a mass. Chap. III.

II. Gold occurs native, only in combination with other metals. It is alloyed by silver, copper, and sometimes iron. In Europe, it is found in Hungary, Sweden, Norway and Ireland. In the tropical regions, where it is by far the most abundant, it occurs in Africa in the sands of rivers; in South America and in India. In the United States, it has been found in North Carolina. How found, and where.

III. To separate gold from earthy or sandy matters, with which it may be mixed, in the form of grains, in nearly a pure state; the method is to reduce the auriferous earth to coarse powder, and afterwards to place it upon a cloth with a long nap, where it may be subjected to the action of a stream of water. By this management, the greater part of the earthy and sandy particles are washed away; while those of the gold, by reason of their greater weight, remain behind entangled in the cloth. The particles, thus obtained, are disengaged from the cloth, and further purified by agitation with water; this acts by suspending the lighter particles, which may be drawn off from those which remain at the bottom. When the gold particles are brought to this state of purification, they are triturated with mercury in an iron vessel containing boiling water. An amalgam of gold is thereby formed; but it is still mixed with earthy matters. These may be separated by farther washings; and finally by laying the whole mass upon an inclined surface; from which the amalgam may be made to run by a little stirring, leaving the impurities behind. After the amalgam is thus obtained in a pure state, it is subjected to distillation; whereby the mercury is driven off in the state of vapour, and the gold is left behind. If it contain silver as it usually does, this metal may be separated by subjecting it, in very thin leaves, to the action of nitric acid. This acid dissolves the silver and leaves the gold untouched. How separated from earths containing it.

IV. Gold is a soft metal of a fine light yellow colour. It is destitute of taste or smell. Its lustre is very considerable. It is the most malleable and ductile of all the metals. In the air or immersed in water, it does not lose its lustre, and is not in the least affected by these fluids. When subjected to a heat of 32° of Wedgewood, it fuses and assumes on the surface, a bright bluish green colour. Properties of gold.

V. Next to platinum, it is the heaviest substance known; being more than nineteen times as heavy as water. Spec. grav. 19·3.

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VI. Gold combines in two proportions with oxygen, and forms protoxide and peroxide of gold.

Gold forms two oxides. 1. Protoxide.

1. *Protoxide of gold* may be obtained by exposing perhydrochlorate (permuriate) of gold to heat, until it ceases to give out chlorine. The chlorine appears in consequence of the decomposition of part of the hydrochloric acid; the corresponding hydrogen of the same acid combines with part of the oxygen of the peroxide, so as to reduce it to the state of protoxide; and thus the perhydrochlorate becomes a simple hydrochlorate. When caustic potash is added to this hydrochlorate, it throws down the protoxide in the form of a powder.

Its properties.

2. This oxide is of a green colour. In a very short time it becomes separated into two parts. Two thirds of it are reduced to the metallic state; the oxygen from which, combining with the other third, converts it into peroxide. It is composed of

Gold	200
Oxygen	8
	208

2. Peroxide

1. *Peroxide of gold* may be formed by dissolving the metal in a mixture of one part of nitric acid, and four parts of hydrochloric (muriatic) acid; and treating the heated solution by potash. A precipitate gradually appears, which must be washed carefully and dried; it consists of the peroxide in question.

Its properties.

2. This peroxide is a tasteless reddish brown powder; insoluble in water, but dissolving readily in hydrochloric (muriatic) acid. A very moderate heat drives off its oxygen and reduces it to the metallic state. It is composed of

Gold	200
Oxygen	24
	224

—From these numbers, it is evident that this oxide contains three times as much oxygen as the protoxide.

Its medical uses.

3. Peroxide of gold, as well as several other compounds of this metal, has been recommended by a French writer for the cure of the venereal disease. But it is believed that the subsequent trials of the preparations of the metal have not confirmed the reports made in its favour.

Chloride of gold.

VII. Chloride of gold may be formed by heating the metal, in a state of minute division, in chlorine gas. It is a brown substance. When exposed to the air, it decomposes moisture, and is converted into perhydrochlorate (permuriate) of gold.

VIII. Phosphuret of gold may be formed by fusing to-

gether in a crucible one part of gold and two parts of dry phosphoric acid, surrounded by charcoal. It is a very brittle substance of a much paler colour than gold. Chap. III.

IX. Sulphuret of gold cannot be formed by fusing together its constituents; but if hydrosulphate of potash or of soda be dropped into a solution of gold, this sulphuret falls in the form of a precipitate. It has a black colour. Sulphuret.

X. Gold combines with the majority of the other metals; but the only combinations of this kind, which will be mentioned here, are those with copper and mercury. Alloy of gold with copper or silver,

1. The alloy of gold and copper is easily formed by fusion. The copper increases the hardness, without injuring the colour of the gold. When gold is prepared for coining, it is alloyed either with this metal, with silver, or with a mixture of both. The gold, if coined perfectly pure, would be too soft for the purposes of money. The quantity of alloying metal, which enters into the composition of the gold coin of the United States, Britain, France and Spain, may be seen by the following table. forms gold coin.

	Parts of pure gold, combined with one part of alloying metal.
Gold coin of the United States contain .	11
——— Britain	11
——— France	9 nearly.
——— Spain	5·5 nearly.

Goldsmiths, to express the purity of gold, suppose its alloys to be divided into 24 equal parts, which they call carats; and the pure gold is expressed in 24th parts. Thus gold said to be 20 carats fine, contains $\frac{20}{24}$ths of pure gold and $\frac{4}{24}$ths of alloying metal. If gold is said to be 24 carats fine, it must be perfectly pure gold.

2. The amalgam of gold is used in some of the methods of gilding. Silver, brass and copper may be gilded by it. The process consists in applying with a brush, a thin layer of the amalgam, upon the metal to be gilded, and then exposing it to the heat of a charcoal fire. The mercury is in this way volatilized, and a thin layer of gold remains covering the metal. Amalgam of gold, used in gilding.

SECTION XV.

OF PLATINUM.

I. Platinum may be obtained pure by the following process: Dissolve the South American ore in aqua regia, and precipitate the solution by hydrochlorate of ammonia (sal Platinum; how obtained pure.

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ammoniac). Dissolve the precipitate in aqua regia also, and precipitate again by hydrochlorate of ammonia. The product of the second precipitation, when heated to whiteness, is pure platinum.

Where found.

II. Platinum has been found heretofore only in Spain; and in three places in South America. Its localities in South America are, near Choco in Peru, at Santa Fé in New Granada, and in a district in the Brazils. It is usually alloyed by a number of metals.

Its discovery.

III. This metal, in its impure state, was first noticed in 1741. Nothing, however, was ascertained of its properties, until Dr. Lewis published his papers on it, in the Philosophical Transactions for 1754.

Properties of platinum

IV. Platinum is a white metal, possessing considerable brilliancy; but inferior in this respect to silver. Its hardness is intermediate between that of copper and iron. It is very ductile and malleable; possessing these qualities in a greater degree than any other metal, except gold. It is one of the most infusible metals. It is not in the slightest degree altered by exposure to air or immersion in water. It is capable of being welded at a white heat. It may be made to burn by subjecting it to the intense heat, produced by the combustion of a stream of oxygen and hydrogen gases.

Spec. grav. 21.47.

V. It is the heaviest body known, being about twenty-one and a half times as heavy as water.

Platinum forms two oxides.

VI. Platinum combines in two proportions with oxygen, and forms protoxide and peroxide of platinum.

1. Protoxide.

1. *Protoxide of platinum* may be obtained by dropping a solution of mercury, into a dilute solution of hydrochlorate (muriate) of platinum in hot water. A powder precipitates, which is a mixture of protochloride of mercury (calomel) and this oxide of platinum. Expose this powder to a heat just sufficient to volatilize the protochloride; what remains will consist of the protoxide of platinum in a state of purity. It is in the form of a powder of a deep black colour.

2. Peroxide

2. *Peroxide of platinum* may be formed by decomposing sulphate of platinum, by pure potash added in excess. A precipitate appears, which must be heated to separate some water. It is then pure peroxide of platinum. Its colour is dark brown; when exposed to a high temperature it is reduced to the metallic state. It dissolves in potash and soda, and in their carbonates.

Platinum forms a protochloride and a

VII. Platinum combines in two proportions with chlorine, and forms protochloride and perchloride of platinum. The protochloride is merely known to exist; its properties or composition have not been ascertained. The perchloride will be noticed in the following paragraphs.

1. Perchloride of platinum may be formed by boiling the metal in strong hydrochloric acid, adding occasionally a little nitric acid. The solution is to be evaporated to dryness, and the dry mass digested in a little hydrochloric acid; which also is to be driven off. The dried residue is to be cautiously heated to redness, and afterwards boiled in a considerable quantity of water. Being separated and dried, it is pure perchloride of platinum. Chap. III. Perchloride.

2. This chloride has a dull olive brown colour. It is infusible and scarcely soluble. It is not altered by exposure to air. When exposed to a red heat, it exhales chlorine, and is reduced to the metallic state.

VIII. Platinum combines in two proportions with phosphorus, and forms protophosphuret and perphosphuret of platinum. It forms a

1. *Protophosphuret of platinum* may be obtained by heating together phosphorus and platinum in an exhausted glass tube. At a temperature below redness, they combine with vivid ignition and flame. It has a bluish-grey colour, and is destitute of taste or smell. protophosphuret, and a

2. *Perphosphuret of platinum* may be formed by heating hydrochlorate of platinum-and-ammonia, (ammonio-muriate of platinum), with two-thirds its weight of phosphorus, in a small retort over mercury. After the union has taken place, the whole must be exposed to a dull red heat to expel every thing volatile: what remains will consist of this perphosphuret. It is a tasteless inodorous substance of an iron-grey colour. perphosphuret.

IX. Platinum appears capable of forming three sulphurets. Platinum forms three sulphurets.

1. *Protosulphuret of platinum* may be formed by heating together equal weights of platinum and sulphur, in an exhausted glass tube; and afterwards exposing the mass formed, nearly to a red heat, to drive off every thing vaporizable. It is a tasteless and inodorous substance of a dull bluish-grey colour.

2. *Deutosulphuret of platinum* may be obtained by precipitating platinum from solution, by means of hydrosulphuric acid (sulphuretted hydrogen). The precipitate obtained must then be heated in a close vessel. It is a tasteless powder of a bluish black colour.

3. *Persulphuret of platinum* may be obtained by exposing a mixture of three parts of ammonio-hydrochlorate (ammonio-muriate) of platinum, and two parts of sulphur to a heat gradually increased to redness, and continued at that temperature, until every thing volatile is driven off. This sulphuret has a dark iron-grey colour. It is not fusible when

exposed to a considerable heat in close vessels; but when subjected to a red heat in the open air, it is decomposed; the sulphur is dissipated, and the platinum is left behind in the metallic state.

Alloys of platinum.

X. The alloys of platinum have not as yet been applied to any useful purpose, if that with copper be excepted. This alloy has been employed, with advantage, for forming the mirrors of reflecting telescopes. Platinum itself may be considered useful in every case, in which hard and indestructible metallic substance is required.

Platinum as a medicine.

XI. Platinum, in solution in aqua regia and combined with soda, has been empoyed, with seeming advantage, in some cases of syphilis.

SECTION XVI.

OF PALLADIUM.

Palladium; how obtained pure.

I. Palladium may be obtained pure by dissolving crude platina from South America in aqua regia, and precipitating the solution, by means of a solution of cyanodide (prussiate) of mercury. The precipitate thus obtained, after being washed, dried and exposed to a strong heat, is converted into pure palladium.

Found in crude platina.

II. Palladium is one of the peculiar metals, which have been detected in the crude platina of South America. It was discovered in 1803 by Dr. Wollaston.

Its properties.

III. Palladium is white, and susceptible of being polished. It is somewhat harder than wrought iron. It possesses some malleability. It undergoes no alteration in the air. It is extremely infusible: in the highest heats that can be raised, it fuses only in minute portions. When fused on charcoal by means of a jet of oxygen, it was made to boil, and at last to undergo combustion; emitting at the same time brilliant sparks.

Spec. grav. 11·55.

IV. It is about eleven and a half times as heavy as water.

Forms but one oxide.

V. Palladium combines with oxygen in one proportion only, and forms oxide of palladium. It may be obtained by heating palladium filings with pure potash, mixed with a little nitrate of potash (nitre). It has a chesnut-brown colour. It is composed of

Palladium	56
Oxygen	8
	64.

Chloride of palladium.

VI. Chloride of palladium may be formed by the agency of heat. Its properties have not been examined.

Chap. III. Sulphuret.

VII. Sulphuret of palladium may be formed by throwing sulphur upon strongly heated palladium. The metal immediately enters into a state of fusion, and the union takes place. It is very brittle, and rather paler than palladium.

SECTION XVII.

OF RHODIUM.*

Rhodium; how obtained pure.

I. Rhodium may be obtained by the following process: Subject crude platina to the action of aqua regia, as long as this menstruum dissolves any thing. Separate the black powder, which will be found to have resisted the action of the aqua regia; and to the clear solution, add a solution of hydrochlorate of ammonia (sal ammoniac): this addition will throw down nearly all the platinum. After separating this precipitate, immerse, into the clear solution, a rod of zinc: this metal throws down rhodium, contaminated with copper, lead, platinum and palladium, in the form of a black powder. By submitting this powder to the action of diluted nitric acid, the copper and lead will be dissolved; while the other metals, which it contains, will remain untouched. What is left after the action of the nitric acid is then dissolved in aqua regia, and chloride of sodium (common salt) added to the solution. The whole is then evaporated to dryness; and the mass obtained will consist of the oxides of rhodium, platinum and palladium in combination with the chloride of sodium. The oxides of platinum and palladium, in this state of combination, are soluble in alcohol; whereas the oxide of rhodium is insoluble. By washing the mass, therefore, repeatedly in alcohol, the oxides of platinum and palladium are removed; so that nothing remains but oxide of rhodium in combination with chloride of sodium. Dissolve this residual compound in water, and place in the solution a rod of zinc: this metal throws down the rhodium in the form of a black powder, which may be fused into a mass along with borax.

Found only in crude platina.

II. Rhodium has been found only in the crude platina from South America. It was discovered by Dr. Wollaston in 1804.

Its properties.

III. Rhodium is a brittle metal of a white colour; and, excepting perhaps iridium, next to be described, the most infusible of the metals. It has the distinguishing property of being insoluble in all the acids.

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* From ῥόδεος, rose-coloured, on account of the red colour of dilute solutions of the salts of this metal.

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IV. It is somewhat more than ten and a half times as heavy as water.

Spec. grav. 10·649. Forms three oxides.

V. Rhodium combines in three proportions with oxygen.

1. *Protoxide of rhodium* may be obtained by exposing rhodium in powder, in an open vessel, to a moderate red heat. It is a black substance, which is insoluble in acids. When heated with tallow, it deoxidizes with detonation. It is doubtful whether this oxide enters into the composition of any salt.

2. *Deutoxide of rhodium* may be formed by heating the metal, in powder, with a mixture of potash and nitrate of potash (nitre), and exposing the resulting mass to the action of sulphuric acid. This acid dissolves off the potash; and what remains consists of the oxide in question. It has a brown colour. It does not enjoy the property of a salifiable base.

3. *Peroxide of rhodium* may be prepared by precipitating the compound of oxide of rhodium and chloride of sodium (soda-muriate of rhodium), by potash, and exposing the precipitate obtained to heat. It has a red colour. It is this oxide which is present in the salts of oxidized rhodium.

SECTION XVIII.

OF IRIDIUM.*

Iridium; how obtained pure.

I. IRIDIUM may be obtained pure by the following process: Expose the black powder, which remains undissolved by the action of aqua regia upon crude platina, mixed with five times its weight of pure soda, in a silver crucible, to a red heat for half an hour. Subject the resulting mass to the action of water, in order to dissolve off the soda. Treat the residue alternately with hydrochloric (muriatic) acid and potash, until it becomes totally dissolved: by the action of the potash a peculiar metal is separated, which will be described in the next section; that part of the residue, however, which dissolves in the hydrochloric acid, consists of iridium. Evaporate the acid solution to dryness; and, in order to get rid of some osmium, dissolve the dry mass in hydrochloric acid, and evaporate the solution until it crystallize. The crystals, thus obtained, will consist of hydrochlorate (muriate) of iridium. Expose them to a high

* From iris, the rainbow; on account of the remarkable variety of colours which this metal exhibits in solutions.

temperature in a platinum crucible; the acid, and the oxygen of the oxide are driven off; so that nothing will remain but pure iridium.

Found only in crude platina.

II. Iridium was discovered in 1803, about the same time, by Tennant and Descotils. It exists only in the crude platina of South America.

Its properties.

III. Iridium is a brittle metal of a white colour. It is the most infusible metal known. It resists the action of all solvents except aqua regia; and this last makes but a slight impression upon it.

Spec. grav. 18·96.

IV. At a mean, it is about nineteen times as heavy as water.

Supposed to form two oxides.

V. Judging from the phenomena, which attend the solution of iridium in hydrochloric (muriatic) acid, it would appear that this metal is capable of forming two oxides; but nothing is known of their individual properties.

SECTION XIX.

OF OSMIUM.*

Osmium; how obtained pure.

I. Osmium may be obtained by the following process: Distil the black powder obtained from crude platina, mixed with nitrate of potash (nitre), at a low red heat: the potash of the nitrate combines with the osmium present in the black powder; and, from this combination, allows it to sublime in the state of oxide. Dissolve the oxide thus obtained in water, and agitate the solution along with mercury: the oxide becomes reduced to the metallic state, and forms a combination with mercury. By distilling this amalgam, the mercury is driven off in the state of vapour, while the pure osmium remains behind.

Found only in crude platina.

II. Osmium was discovered by Tennant in 1804. Like the two metals last described, it has been found only in the crude platina from South America.

Its properties.

III. Osmium has a dark-blue colour, and the metallic lustre. When exposed, in close vessels, to a white heat, it does not melt or undergo any change; but, when heated in the open air, it becomes oxidized, and evaporates with a peculiar smell, resembling that of chlorine. After being exposed to heat, it is not acted upon by any acid. Its weight, compared with that of water, has not been ascertained.

* From ὀσμὴ, odour; from the remarkable property of this metal, of possessing a peculiar odour in solution.

IV. Osmium combines in one proportion only with oxygen, and forms oxide of osmium.

Forms but one oxide. 1. This oxide may be formed by heating osmium in the open air. The metal combines with oxygen; but the heat applied volatilizes the oxide. It may be obtained in the solid form by distilling the black powder of crude platina with nitrate of potash (nitre), as mentioned in the beginning of the present section. A substance sublimes, which consists of the oxide in question.

Its properties. 2. Oxide of osmium, obtained by the last-mentioned process, when cool, is a solid semi-transparent mass. Its solution in water is colourless, and has a sweetish taste and strong peculiar smell. It does not alter the colour of vegetable blues. When shaken with mercury, it loses its peculiar smell, the osmium becomes deoxidized, and forms an amalgam. It stains the skin of a dark colour. It is precipitated by all other metals, except gold and platinum; the osmium being reduced to the metallic state.

V. Researches into the compounds, which osmium forms with other bodies, have not been made to any extent. Two or three alloys have been formed; but these are too unimportant to be described.

SECTION XX.

OF TITANIUM.

Titanium; how obtained pure. I. Titanium may be obtained by the following process: Fuse the mineral called titanite, which consists of oxide of titanium nearly pure, with five or six times its weight of carbonate of potash (salt of tartar), and wash the mass obtained until every thing soluble be abstracted. Digest the residue with boiling hydrochloric (muriatic) acid: a white powder will remain, which has resisted the action of the acid; it consists of peroxide of titanium. It may be deoxidized by exposure to a violent heat, mixed with oil, in a charcoal crucible.

How found. II. Titanium has been found in the state of oxide, either pure, or combined with iron, or with silica. It occurs in England, Scotland, France and Hungary. In the United States, it has been found in Virginia, in the state of oxide.

Account of its discovery. III. Titanium in an oxidized state was first obtained, in 1781, by Gregor, from a mineral, resembling black sand, which was found in the valley of Menachan in Cornwall, and hence called menachanite. Gregor had every reason to

believe that the powder, which he had discovered, was a metallic oxide; but he was unable to reduce it to the metallic state. In 1795, Klaproth obtained the same powder from the mineral called red schorl, and with the same evidence of its metallic nature; but he, like Gregor, in vain attempted its reduction. In 1796, however, Vauquelin and Hecht succeeded in reducing minute portions of the powder to the metallic state. Gregor ought nevertheless to be considered as the discoverer of this metal; since the last mentioned chemists did nothing more than to verify his original opinion respecting its oxide.

Properties of titanium.

IV. Titanium is a very brittle metal, of a colour resembling that of copper. It possesses considerable lustre, but tarnishes in the air. It is extremely infusible; the highest heat, which can be raised, produces its fusion but imperfectly. Its specific gravity has not been ascertained.

Titanium forms three oxides.

V. Titanium combines with oxygen in three proportions, and forms protoxide, deutoxide, and peroxide of titanium.

1. Protoxide of titanium may be formed by heating titanium in the open air. It has a blue or purple colour.

2. Deutoxide of titanium has a red colour. It constitutes the mineral called red schorl or titanite. Its hardness is sufficient to enable it to scratch glass. When heated, it becomes brown; and afterwards, if the fire be urged violently, it is, in part, volatilized.

3. Peroxide of titanium may be obtained by fusing the deutoxide with four times its weight of potash, and treating the mass obtained by water. A white powder will remain behind, which consists of the peroxide in question.

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With the preceding description of titanium, the account of the undecompounded ponderable bodies is completed. They amount to 51 in number. There are

4 supporters of combustion;
1 incombustible, and
46* combustibles.

The classification of these bodies, pursued in the present work, may be seen in the following table.

* Cadmium and Wodanium are not included in this enumeration.

TABLE,

EXHIBITING THE ARRANGEMENT OF THE UNDECOMPOUNDED PONDERABLE BODIES.

UNDECOMPOUNDED PONDERABLE BODIES.	I. Supporters of combustion.			1. Oxygen. 2. Chlorine. 3. Iodine. 4. Fluorine.
	II. Incombustibles.			1. Azote.
	III. Combustibles.	I. Acidifying combustibles.		1. Hydrogen.
		II. Acidifiable combustibles.		1. Carbon. 2. Boron. 3. Phosphorus. 4. Sulphur. 5. Arsenic. 6. Chromium. 7. Molybdenum. 8. Tungsten. 9. Columbium. 10. Selenium.
		III. Intermediate combustibles.		1. Antimony. 2. Tellurium.
		IV. Basifiable combustibles.	*a.* Basifiable combustibles, forming, with oxygen, alkaline salifiable bases; or, alkalifiable combustibles.	1. Potassium. 2. Sodium. 3. Lithium. 4. Calcium. 5. Barium. 6. Strontium. 7. Magnesium.
			b. Basifiable combustibles, forming, with oxygen, earthy salifiable bases.	1. Yttrium. 2. Glucinum. 3. Aluminum. 4. Zirconium. 5. Thorinum. 6. Silicum.
			c. Basifiable combustibles, forming, with oxygen, salifiable bases, having neither alkaline nor earthy properties.	1. Iron. 2. Nickel. 3. Cobalt. 4. Manganese. 5. Cerium. 6. Uranium. 7. Zinc. 8. Lead. 9. Tin. 10. Copper. 11. Bismuth. 12. Mercury. 13. Silver. 14. Gold. 15. Platinum. 16. Palladium. 17. Rhodium. 18. Iridium. 19. Osmium. 20. Titanium.

CHAPTER IV.

ACCOUNT OF THE ARRANGEMENT OF THE UNDECOMPOUNDED PONDERABLE BODIES.

Arrangement of undecompounded ponderable bodies, founded upon that pursued by Dr. Thomson.

The arrangement of these bodies, as seen by the table, is in many respects different from that adopted by Dr. Thomson; although founded on the classification of this author. The work of Dr. Thomson has been constantly before me; and I do not know whether the same arrangement would have occurred to me, if I had never seen his system. Be that as it may, the truth is, I never hesitated to alter his arrangement; when, upon careful consideration, a conviction was felt, that the alteration would tend to simplification and precision. In short, I never altered, merely for the sake of altering; neither did I, in any case, give up my mature judgment, merely because it differed from that of a chemist of high authority.

In as concise a way as possible, I shall take notice of the alterations which have been made in Dr. Thomson's arrangement; and afterwards mention what appear to be the principal defects of the classification, as it stands in the present work.

It agrees with Dr. Thomson's, in its primary divisions.

The arrangement adopted, in its primary divisions, agrees with that of Dr. Thomson: the undecompounded ponderable bodies are divided into supporters of combustion, incombustibles, and combustibles.

Dr. Thomson divides combustibles into three genera.

Dr. Thomson divides the combustibles into three genera, which he defines in the following words.

" I. Bodies forming *acids* by uniting with the supporters of combustion or with hydrogen."

" II. Bodies forming *alkalies or bases*, capable of constituting neutral salts with acids, by uniting with the supporters of combustion."*

" III. Bodies producing by their union with the supporters of combustion, imperfect acids, or substances intermediate between acids and alkalies."†

As introductory to the account of the third genus, Dr. Thomson gives the following distinguishing characters to the bodies included under that head.

" The substances belonging to this genus may be considered as intermediate between the first and the second

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* Thomson's Chemistry, vol. I. p. 220. † Ibid. p. 221.—Ed. 1817.

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genus. They differ from those of the second genus, by forming compounds with oxygen, which do not neutralize acids; and from those of the first genus, by not entering into any gaseous combinations. They agree with the bodies of the first genus; because their oxides possess acid properties. They agree with the bodies of the second genus; because these acids are but imperfectly soluble in water, and act with but little energy upon animal and vegetable bodies."*

What bodies Dr. Thomson includes under his first genus; what, under his second genus;

Under his first genus, Dr. Thomson gives hydrogen, carbon, boron, silicum, phosphorus, sulphur, arsenic, and tellurium; to which he adds osmium from analogy.

Under the second genus, he includes the following bodies, divided into five families. 1st Family; Potassium, sodium, calcium, barium, strontium, magnesium. 2d Family; Yttrium, glucinum, aluminum, zirconium, thorinum. 3d Family; Iron, nickel, cobalt, manganese, cerium, uranium. 4th Family; Zinc, lead, tin, copper, bismuth, mercury, silver. 5th Family; Gold, platinum, palladium, rhodium, iridium.

and what, under his third

Under the third genus, he gives antimony, chromium, molybdenum, tungsten, columbium, titanium.

Arrangement adopted has a set of acidifiable combustibles;

In my arrangement of the combustibles, I have a class of acidifiable combustibles. But the definition of it is different from that, given to the corresponding class by Dr. Thomson, as may be seen by the table. It includes such combustibles as form acids, and in no case salifiable bases, by uniting with *oxygen*. Hydrogen, therefore, is excluded from it, as this combustible forms no acid with oxygen; and is erected into a separate class, for reasons which will be given presently. Silicum is excluded also; because the proofs of its oxide (silica) being an acid are not satisfactory. Tellurium is excluded; because it forms a compound with oxygen, which performs the part of a base, as well as of an acid. The definition, however, while it excludes some bodies of Dr. Thomson's genus, embraces others, not included in his. Thus chromium, molybdenum, tungsten and columbium are brought in here, from Dr. Thomson's third genus, where they are called bodies capable of forming with oxygen imperfect acids; because they form acids with oxygen, but never salifiable bases.†

which constitute the second class.

The acidifiable combustibles, as just enumerated, form the second class of combustibles in the table. The first contains one body only, and that is hydrogen.

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* Thomson's Chemistry, vol. I. p. 528.

† Selenium has been classed with the acidifiable combustibles, since the above was written.

There are a number of acids, which agree, as to constitution, in no other particular than in containing hydrogen. These are hydrochloric (muriatic) acid, hydriodic acid, hydrosulphuric acid (sulphuretted hydrogen), hydroselenic acid (selenuretted hydrogen), hydrotelluric acid (telluretted hydrogen), hydrofluoric (fluoric) acid, and hydrocyanic (prussic) acid. It is for this reason that I have put hydrogen in a class by itself, and ventured to call it an acidifying body. The term *acidifying* is not meant to convey the idea of any exclusive agency of the hydrogen in the production of the acid properties, in the particular acids above mentioned; but it is used as being convenient, and best suited to express the idea. It is, certainly, equally admissible with the term acidifiable; since an active participle may be used with the same propriety as the passive potential.

The first class contains hydrogen only; which is called an acidifying combustible.

Besides, hydrogen does not stand well along side of the bodies, with which Dr. Thomson has associated it in his first genus. Excepting hydrogen, all the bodies of this genus form acids with oxygen, (assuming Dr. Thomson's opinion respecting silicum), and agree very well in this particular. Hydrogen, however, forms no acid with oxygen; while with sulphur, one of the substances, also included in the genus, it forms a compound having acid properties.

Arrangement in this particular justified.

The title of my third class is adopted from Dr. Thomson; but by intermediate combustibles, I do not mean the same thing with this author. He understands by intermediate combustibles, such bodies as form "by their union with the supporters of combustion, imperfect acids, or substances intermediate between acids and alkalies." Under the acceptation in which the term is here taken, it designates those combustibles, which, by union with oxygen, form compounds, which act the part of acids and of bases, in different cases of combination. Hence the reason that chromium, molybdenum, tungsten, and columbium are carried into the second class in this work; since the oxides of these bodies, which enter into the constitution of salts, always take the part of acids, and in no case of salifiable bases. Titanium also is excluded from the class of intermediate combustibles, where Dr. Thomson has placed it; as not answering to the meaning of the term, as here adopted. It does not, in fact, answer to its meaning, as explained by Dr. Thomson himself; who nowhere, in his work, ascribes, to its compounds with supporters, acid properties of any kind; or any other properties, which would justify the belief, that they are substances intermediate between acids and alkalies.

Title of third class of combustibles, borrowed from Dr. Thomson; but the term *intermediate* taken in a new acceptation.

Under the particular acceptation, in which the title *intermediate combustibles* is here taken; I retain but one body

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placed under this head by Dr. Thomson; and that is antimony. It is because this metal forms compounds with oxygen, one of which performs the part of a salifiable base; while the others (antimonious and antimonic acids) perform the part of acids. Tellurium, which was excluded from Dr. Thomson's genus of acidifiable combustibles, is inserted here; because the only compound which it forms with oxygen is sometimes an acid and sometimes a salifiable base. The reader, however, will observe this difference between antimony and tellurium; that while the respective offices of acid and of base are performed by different oxides of antimony; both these offices belong to the only oxide, which tellurium is capable of forming.

Two bodies only retained under the title of intermediate combustibles.

Thus it is perceived that the class of intermediate combustibles is made to embrace but two bodies; antimony and tellurium. It is placed next to the class of acidifiable combustibles; in order that the bodies, which it embraces, may stand as close as possible to the acidifiable metals, to which they bear a very close analogy.

Combustibles embraced under the fourth class called basifiable.

My fourth class is called by the title of *basifiable combustibles*. It corresponds exactly with Dr. Thomson's second genus, as far as the definition is concerned. But besides the bodies included under it by this chemist; I have added silicum, to which its old position is given; osmium, because the force of analogy is not sufficiently strong to justify its position among the acidifiable combustibles; and titanium, for the reasons which excluded it from the class of intermediate combustibles.

This class divided into three sub-classes.

I do not retain the families into which Dr. Thomson has divided this class; because they have no well marked characters, except the first and second. The class is divided, in the present work, into three sub-classes: the first sub-class embraces alkalifiable combustibles;* the second, combustibles forming earthy salifiable bases; and the third, combustibles forming salifiable bases, having neither alkaline nor earthy properties.

Thus I have given the reasons, which induced me to modify Dr. Thomson's arrangement of the undecompounded ponderable bodies. Indeed, I have taken so many liberties with it, as to change almost entirely its aspect; and, while the arrangement of the present work bears resemblance to it, in some respects; in others, it is totally different. It is confessedly founded upon the arrangement of Dr. Thom-

* This sub-class contains lithium, in addition to the bodies included under it by Dr. Thomson. Lithium was not known when the last edition of this chemist's work was put to press.

son; and when I first undertook to prepare this volume, from materials, drawn, principally, from his copious work, I had not conceived the design of altering it. But in my progress there appeared to be several alterations which could be made with advantage. These, however, were not made hastily; for I gave every point very scrupulous attention, in order to see whether further investigation would destroy my first impressions; and, not till after I was unable to convince myself that I was wrong, did I adopt the modifications.

I should not have employed so much time in giving the preceding account of the arrangement, which I have adopted; but that I have attempted to substitute something, in many respects my own, for what has received the approbation of a respectable portion of the chemists of the day. Unknown as I am in chemistry, my suggestions in the scientific arrangement of its objects can have no weight of authority; but must stand upon their intrinsic merits, and depend, for their adoption, upon the exhibition of satisfactory reasons.

Prominent defects of the arrangement as adopted.

After all the attention I have bestowed upon the arrangement of chemical bodies, I freely acknowledge, that, in several respects, the one which is adopted is far from being satisfactory. In the first place, it is not probable that the phenomena, attendant on combustion, will long continue to afford a convenient basis, upon which to erect the primary divisions of chemical bodies. Already is the class of supporters swelled to four by the addition of bodies, which do not stand well associated with oxygen; and yet it does not contain all the bodies which legitimately belong to it. Potassium, sulphur and phosphorus are as fully entitled to be called supporters as iodine or fluorine; because, in some of their combinations with bodies not supporters, the chemical action is so intense as to produce both sensible light and heat. Thus it is perceived, that, under the definition of a supporter, bodies, in many respects dissimilar, would be unnaturally grouped together, and the end of scientific arrangement thereby defeated.

Again, all the substances, which are arranged under the title of combustibles, forming salifiable bases, with oxygen, having neither alkaline nor earthy properties, in strict propriety do not belong here. Without doubt, the oxides of cerium, of uranium, of titanium, and of some other metals arranged here, are as perfect earths as yttria, glucina, or any of the other bodies, which have generally been denominated earths. Hence there is no reason why these

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metals should not be classed along with the basifiable combustibles, forming earthy bases with oxygen.

Having thus finished the account of the arrangement of the undecompounded ponderable bodies, pursued in this work; it may not be without its use to recapitulate, in tables, their more important properties.

Table of the Supporters of Combustion, Incombustibles, and the Acidifying Combustibles.

Names of the Bodies.	Discoverers, and time of discovery.	Synonymes.	State as to aggregation at the common temperature of the air.	Colour.	Smell.	T[illegible]	Quantity soluble in 100 cubic inches of water; in cubic inches.	Specific Gravity.		Relation to combustion.	Relatio[n to] spirat[ion]
								Compared with air as unity.	Compared with water as unity.		
1. Oxygen.	Priestley; 1774.	Dephlogisticated air; vital air.	Gaseous.	Colourless.	Inodorous.	Insipid.		[illegible]		Supporter.	Resp[irable]
2. Chlorine.	Discovered by Scheele; 1774. True nature made out by Davy and Gay-Lussac.	Dephlogisticated muriatic acid; oxymuriatic acid.	Gaseous.	Greenish-yellow.	Strong and suffocating.		200·00.	2·4700		Supporter.	Unres[pirable] noxi[ous]
3. Iodine.	Courtois; 1811.		Solid.	As a solid, greyish-black. As vapour, violet.	Similar to, but not so strong as that of chlorine.	Acrid and hot.	Very sparingly soluble.	As vapour 8·678.		Supporter.	
4. Fluorine.	Existence made probable by Davy; 1810.		Probably solid.	White, in combination with Potassium.*							
5. Azote.	Rutherford; 1772.	Phlogisticated air; nitrogen gas.	Gaseous.	Colourless.	Inodorous.	Insipid.	1·47.	[illegible]		Incombustible.	Respira[ble] not ca[pable of] suppo[rting] life.
6. Hydrogen.	Cavendish; 1766.	Light inflammable air.	Gaseous.	Colourless.	Inodorous.	Insipid.	[illegible]	0·0732.		Combustible.	Respira[ble] not ca[pable of] suppo[rting] life.

* Nothing more is known of this substance; it never having been obtained in a separate state.

Table of the Acidifiable Combustibles.

Smell	Specific Gravity compared with water unity.	Melting Point.	Point of vaporization, or volatilization.	Acids formed, of which each body is the base.
	0·441.			Carbonic acid.
	After exposure to heat; [illegible]		Not volatilizable.	Boracic acid.
				Hypophosphorous acid. Phosphorous acid. Phosphoric acid.
Inodorous.				Hyposulphurous acid. Sulphurous acid. Sulphuric acid. Hydrosulphurous acid. Hydrosulphuric acid.
Inodorous when cold; but smelling like garlic when heated.				Arsenious acid. Arsenic acid.
				Chromic acid.

* All the bodies described in this table are solids, at the common temperature of the air.
§ The beginning of Wedgewood's scale corresponds with 947° of Fahrenheit's, or a red heat; and every degree of it is equal to 130° of the latter.

Table of the Acidifiable Combustibles (continued) and of Intermediate Combustibles.

	Discove and tim lscovery	…	…at of vapo- ration or vo- latilization	Acids formed, of which each body is the
	…ergman Hjelm 1782.			
	…eurs. I huyart 1783.			
	Hatchett Ekeber 1801.			
	Berzelius 1818.			
1. Antimony.	Basil Val tine: end … 15th centu…			
2. Tellurium.	Klaproth 1798.			

* All the bodies described in this Table are solids, at the common temperature of the air.

Table of the Basifiable Combustibles.

Names of the Bodies.	Discoverers, and time of discovery.	State as to aggregation, at the common ---ature of the	Colour.
1. Potassium.	Davy; 1807.	Solid.	White.
2. Sodium.	Davy; 1808.	Solid.	hite; bet at of silve id.
3. Lithium.	Davy; 1818.	Solid.	White.
4. Calcium.	Berzelius a tin, and D 1808.	Solid.	embling of silver
5. Barium.	Berzelius Pontin; 1808.	Solid.	embling of silver
6. Strontium.	Davy; 1808.	Solid.	White.
7. Magnesium.	Davy; 1808.	Solid.	White.

Table of the Basifiable Combustibles,—Continued.

Names of the Bodies.	Discoverers, and time of discovery.	State as to gation, common perature air.
8. Yttrium.	Davy; 1808.	Solid.
9. Glucinum.	Davy; 1808.	Solid.
10. Aluminum.	Davy; 1808.	Solid.
11. Zirconium.	Davy; 1808.	Solid.
12. Thorinum.	Existence rendered probable by Berzelius; 1815.	
13. Silicum.	Berzelius and Davy; 1808.	Solid.
14. Iron.	Known from the earliest ages.	Solid.

Table of the Basifiable Combustibles,—Continued.

Names of the Bodies.	Discoverers, and time of discovery.	State as to aggregation, at the common temperature of the air.	Colour.	S		ific Gravity, npared with ter as unity.	Melting Point. Fahrenheit.	Melting Point. Wedgewood.
15. Nickel.	Cronstedt; 1751.	Solid.	White.			8·402.		
16. Cobalt.	Brandt; 1733.	Solid.	Grey, with a tint of red.	Scar		8·53.		
17. Manganese.	Kaim and Gahn; between 1770 & 1775.	Solid.	Greyish-white, Like that of cast-iron.	Inc		8·013.		
18. Cerium.	Berzelius & Davy; between 1804 & 1807.	Solid.	Deep-grey.					
19. Uranium.	Klaproth; 1789.	Solid.	Iron-grey.			8·100.		
20. Zinc.	Unknown.	Solid.	White, with a shade of blue.	Perceptible.	Peculiar.	6·861.		
21. Lead.	Known from the earliest ages.	Solid.	Bluish-white.	Peculiar, when rubbed.	Perceptible.	11·352		

Table of the Basifiable Combustibles,—Continued.

Names of the Bodies.	Discoverers, and time of discovery.	State as to aggregation, at the common temperature of the air.	Colour.	S	Specific Gravity, compared with water as unity.	Melting Point. Fahrenheit.	Melting Point. Wedgewood.
22. Tin.	Known from the earliest ages.	Solid.	White, like that of silver.	Pecul ra	7·291.		
23. Copper.	Known from the earliest ages.	Solid.	Red.	Peculia agr	8·895.		
24. Bismuth.	Not known in a pure state before the middle of the 18th century.	Solid.	White, with a tint of red.	Ino	9·822.		
25. Mercury.	Known from the earliest ages.	Liquid.	White, like that of silver.	Ino	3 568.		
26 Silver.	Known from the earliest ages.	Solid.	Brilliant white, with a shade of yellow.	Inod	0·474		
27 Gold.	Known from the earliest ages.	Solid.	Fine light yellow.	Inod	19·3.		

S

Table of the Basifiable Combustibles,—Concluded.

Names of the Bodies.	Discoverers, and time of discovery.	State as to aggregation, at the common temperature of the air.	Colour.	Melting Point. Fahrenheit.	Melting Point. Wedgewood.
28. Platinum.	Lewis; 1754.	Solid.	White, but brilliant thai of silver.		170° +
29. Palladium.	Wollaston; 1803.	Solid.	White.		170° +
30. Rhodium.	Wollaston; 1804.	Solid.	White.		160° +
31. Iridium.	Tennant and Descotils; 1803.	Solid.	White.		160° +
32. Osmium.	Tennant; 1804.	Solid.	ark-blu	Very infusible.	
33. Titanium.	Vauquelin and Hecht; 1796.	Solid.	ike that copper.		170° +

TABLE

Of the Specific Gravities, as far as they are known, of the Undecompounded Ponderable Bodies, given in the order of their relative amounts.

Compared with air as unity.			*Compared with water as a unity.*		
1. Hydrogen	0·0732		20. Zinc	6·861	
2. Azote	0·978		21. Tin	7·291	
3. Oxygen	1·108		22. Iron	7·7	medium.
4. Chlorine	2·4700		23. Manganese	8·013	
Compared with water as unity.			24. Uranium	8·100	
5. Potassium	0·865		25. Arsenic	8·31	
6. Sodium	0·972		26. Nickel	8·402	
7. Magnesium	1 +		27. Cobalt	8·53	
8. Phosphorus	1·770		28. Molybdenum	8·611	Bucholz.
9. Boron	1·844		29. Copper	8·895	
10. Sulphur	1·990		30. Bismuth	9·822	
11. Carbon { charcoal	0·441		31. Silver	10·474	
11. Carbon { diamond	3·5		32. Rhodium	10·649	
12. Barium	4·5	estimated.	33. Lead	11·352	
13. Strontium	4·5	estimated.	34. Palladium	11·55	medium.
14. Selenium	4·6		35. Mercury	13·568	
15. Iodine	4·948		36. Tungsten	17·4	
16. Columbium	5·61		37. Iridium	18·96	medium.
17. Chromium	5·90		38. Gold	19·3	
18. Tellurium	6·115		39. Platinum	21·47	
19. Antimony	6·712				

The undecompounded bodies, whose specific gravities have not as yet been ascertained, are fluorine, lithium, calcium, yttrium, glucinum, aluminum, zirconium, thorinum, silicum, cerium, osmium, and titanium.

CHAPTER V.

SKETCH OF THE ATOMIC THEORY OF CHEMICAL COMBINATION.

At this stage in the progress of the present work, it appears to be most expedient to introduce to the notice of the reader, the leading facts known respecting the proportions and the manner in which bodies unite chemically. Object of this chapter stated.

For the purpose of illustration, a set of bodies will be selected; and the quantities in which each of them combines with oxygen and hydrogen, both taken at unity, will be noted.

Statement of chemical proportions.

One part of Oxygen combines with	4·5 parts of chlorine,		forming protoxide of chlorine.
	·75	carbon,	carbonic oxide.
	1 5	phosphorus,	phosphorous acid.*
	2.	sulphur,	hyposulphurous acid.

One part of Hydrogen combines with	4·5 + 8 or 36 parts of chlorine,		forming hydrochloric acid.
	·75 + 8 or 6	carbon	hydroguret of carbon.
	1·5 + 8 or 12	phosphorus	hydroguret of phosphorus.
	2 + 8 or 16	sulphur	hydrosulphuric acid.

Deduction from this statement;

From the above statement, it must be evident, that whatever quantity of chlorine, carbon, phosphorus or sulphur, combines with a given quantity of oxygen; eight times such quantity unites with the same amount of hydrogen.

which is only true under certain circumstances.

The proposition, however, as just stated, is only true of the compounds spoken of, when their constituents combine in the simplest proportions. But when one body combines with another in more than one simple proportion; every new proportion is some multiple of the first.

Proposition deduced from statement given, universally true, when bodies unite in the simplest proportions.

Now, the proposition just made, with respect to oxygen and hydrogen, is not only true with regard to their combinations with chlorine, carbon, phosphorus and sulphur; but also with regard to those compounds, which they form with all other substances; at least as far as such compounds have been carefully investigated. So that it may be stated as universally true, that the quantities in which bodies combine, chemically, with any one body, in the simplest proportion, are invariably proportional to the quantities in which the same bodies combine with any other body.

Proposition extended; and

It is further found, that when two bodies, *a* and *b*, combine with a third *c*; by whatever multiple the quantity in which *c* combines with *b*, exceeds the quantity in which *c* combines with *a*; then, in the combination of *a* and *b*, by the same multiple will the quantity *a* exceed the quantity *b*.

illustrated by an example.

For example: both oxygen and hydrogen combine with chlorine; 1 part of oxygen with 4·5 of chlorine; 1 part of hydrogen with 36 of chlorine. Now 36 is 8 times 4·5; therefore the quantity in which chlorine combines with hydrogen, exceeds that in which it combines with oxygen, by the multiple 8. But one part of oxygen combines with the eighth part of one of hydrogen or 0·125; therefore by the same multiple, by which the quantity of chlorine combining with hydrogen, exceeds the quantity of the same body uniting

* The composition of all the chemical compounds, which are selected, for the purpose of illustration in this chapter, will not be found in the preceding part of this volume. It would not be easy to give even a tolerably clear account of the atomic theory, if the illustrations were drawn only from the compounds already described. The reader is, therefore, requested to take for granted the compositions, with which he finds himself not previously acquainted, and which are only anticipated from the necessity of the case.

with oxygen; does the quantity of oxygen exceed the quantity of hydrogen in the combination of oxygen and hydrogen.

Now the reader will bear in mind, that what is here said of oxygen, hydrogen, and chlorine, applies to all other bodies, whose combinations have been accurately ascertained.

If the question be asked, why hydrogen combines with 8 times as much of any body as oxygen does; the probable explanation may occur to the reader, if he advert to the fact, that, in the compound formed by these two bodies, the hydrogen constitutes ⅛th only of the amount of the oxygen; and he may say, that as the hydrogen is assumed as one, which is 8 times greater than its proportional equivalent, compared with that of oxygen taken at unity also; then in that relative amount, it combines with 8 times as much of another body as oxygen does. But if taken at its simple equivalent, which is one-eighth of 1, or 0·125; then that quantity of hydrogen combines exactly with the same quantity of any other body, as 1 of oxygen does: or, to express the same thing without a decimal, 1 part of hydrogen combines with the same quantity of any other body, as 8 parts of oxygen do.

The law of combination, last stated, holds good with regard to all compounds, whose constituents unite in simple proportions. So that if the chemist should find that the simplest combination of hydrogen and sulphur contained 1 part of the former and 16 of the latter; he would be able to infer, that the same quantity of any body, which combines, simply, with 1 part of hydrogen, will unite, in the same manner, with 16 parts of sulphur.

The leading propositions relating to definite chemical proportions are now stated; and

The reader has now been made acquainted with several remarkable coincidences in the proportional numbers, in which chemical bodies combine: it is natural for him to inquire, upon what peculiarities in the manner of their combination do these depend?

The explanation of this point cannot be made to rest upon absolute proof; but upon a train of reasonings so exact in all its parts, as to make it almost universally admitted.

If it be supposed, that, when two bodies unite chemically, it is either a union of 1 atom of one of them, with 1 atom of the other; or 1 atom of one, with 2 atoms of the other; or 2 atoms of one with 3 atoms of the other, and so on for any number of atoms; then it will follow, that, in any compound, whose constituents, there is reason to believe, unite atom with atom, the relative weights of such atoms must

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be proportional to the relative weights of the constituents themselves. Thus if oxygen and hydrogen be supposed to unite one atom with one atom, when they combine to form water; then since the weight of the hydrogen is to the weight of the oxygen as 1 to 8; therefore, if the weight of an atom of hydrogen be assumed as 1, the weight of an atom of oxygen will be 8.

the occurrence of these definite proportions may be accounted for, most satisfactorily, by supposing that bodies combine chemically by atoms, which have different weights.

Now, if it be reasonable, in the nature of things, to suppose that bodies unite atom to atom; and if, upon assuming the supposition as true, it be found that the proportions, in which the constituents of the bodies most familiar to the chemist combine, tally exactly with it; is not the conclusion almost irresistible, that such supposition is not only reasonable, but absolutely true, in the nature of things.

If it be asked, what data the chemist has for supposing that hydrogen and oxygen unite atom with atom, and not in any other atomical proportion; the answer is that hydrogen and oxygen combine in one known proportion only; and that it is not probable that any other proportion of combination will hereafter be discovered. Accordingly it is reasonable to suppose that, if hydrogen and oxygen unite atomically, they combine atom with atom. Upon any other supposition, it would become necessary to consider the only compound of oxygen and hydrogen known, as one in which the constituents unite in unequal numbers of atoms.

The supposition of combination by atoms, assumed; and their weights in different bodies deduced from various data.

The reader, it is believed, will be ready to allow, therefore, that if hydrogen and oxygen unite atomically, the union takes place atom with atom; and if so, that, taking the weight of an atom of hydrogen as 1, the weight of an atom of oxygen will be 8.

The supposition of atomic combination will now be made with regard to several other compounds; and first to hydrochloric (muriatic) acid. This acid is composed of 1 part of hydrogen united to 36 parts of chlorine. Now supposing its constituents united atom with atom; the weight of an atom of hydrogen being taken as 1, the weight of an atom of chlorine will be 36.

Hydriodic acid is composed of 1 part of hydrogen, united to 125 parts of iodine. Now if this be a compound, in which the constituents unite one atom with one atom; then the relative weight of an atom of iodine will be 125.

Hydrosulphuric acid (sulphuretted hydrogen) is composed of 1 part of hydrogen, united to 16 parts of sulphur. Supposing this to be a combination of one atom with one atom also; then the relative weight of an atom of sulphur will be 16.

Thus, taking the weight of an atom of hydrogen as one (and

unity will always be assumed to express the atom of this body) then the relative weight of the atom

Of Chlorine will be	36
Of Iodine	125
Of Sulphur	16—as deduced from

the composition of the three acids just mentioned.

The relative weights of the atoms of these same bodies will now be deduced from their combinations with oxygen.

Oxygen combines in four proportions with chlorine. The compounds formed are composed as follows:

1. Protoxide of chlorine, of	8 oxygen	+ 36	chlorine.
2. Deutoxide of chlorine, of	32 ——	+ 36	——
3. Chloric acid, of	40 ——	+ 36	——
4. Oxychloric (perchloric) acid,	56 ——	+ 36	——

Now as the protoxide of chlorine is the particular combination, between oxygen and chlorine, in which the constituents combine atom with atom, for reasons of general application, which will be given hereafter; the relative weight of an atom of chlorine must be deduced from this oxide: and it is perceived, that it turns out to be the same, as when deduced from the combination of this same supporter with hydrogen.

It is also perceived, that the deutoxide contains 4 times, chloric acid, 5 times, and oxychloric (perchloric) acid, 7 times as much oxygen, combined with the same quantity of chlorine, as the protoxide. Here then the chemist infers that these compounds are composed of 1 atom of chlorine, combined respectively with 4 atoms, with 5 atoms, and with 7 atoms of oxygen.

Iodic acid is the only compound formed between iodine and oxygen; it is composed of

8 oxygen + 25 iodine; or, which is the same thing, of 40 —— + 125 ——

From the above numbers, it is necessary to infer, either, that the atom of iodine is rated 5 times too high, as deduced from its combination with hydrogen; or that the compound in question contains five atoms of oxygen. The latter inference is by far the most probable; since the weight of an atom of iodine, deduced from a number of its compounds, turns out to be the same as when calculated from hydrogen.

Oxygen forms with sulphur three compounds, which are composed as follows:

1. Hyposulphurous acid of	8 oxygen	+ 16	sulphur.
2. Sulphurous acid of	16 ——	+ 16	——
3. Sulphuric acid of	24 ——	+ 16	——

Supposing hyposulphurous acid to be the particular compound of the three, in which the constituents are united in the simplest atomic manner; then it is obvious that the weight of the atom of sulphur will be 16, the same number assigned for it, from the consideration of its combination with hydrogen. It is also obvious, from the foregoing statement, that sulphurous acid contains two, and sulphuric acid, three atoms of oxygen, united with one atom of sulphur.

These weights, so deduced, turn out to be the same for the same body.

The fair conclusion to be drawn from the above statements is, that the same relative weights, for the atoms of chlorine, iodine, and sulphur, are deducible from the combinations of these bodies, with either hydrogen or oxygen.

If then, there is good reason to believe that the relative weights, of the atoms of chlorine, iodine and sulphur are correctly stated at 36, 125, and 16 respectively; it may be matter worthy of inquiry, what relative weights would be assigned to these same bodies by the consideration of the combinations formed between themselves. These combinations are chloriodic acid, chloride of sulphur, and iodide of sulphur. One only of these substances has been accurately analyzed; and the proportion, in which its constituents combine, confirms the statement above given. Thus chloride of sulphur is composed of 36 parts of chlorine united to 16 parts of sulphur. Chloriodic acid and iodide of sulphur afford no data; as their composition is not correctly known.

How a combination in its simplest proportions is to be known.

In the foregoing observations, the reader has been told that bodies probably combine by atoms: and that whenever there is good reason to believe that the constituents of any body combine one atom with one atom; then the numbers which express the relative weights of such constituents, represent also the relative weights of their atoms. But, it may be asked, what are the indications which make it probable, when several different compounds are formed from the same constituents combining in different proportions, that some one of them is formed by the union of one atom with one atom; and not by the union of an unequal number of atoms.

To illustrate this question, it will be convenient to adduce an instance, in which a number of compounds are formed from the same constituents, united in different proportions; and to consider them with the view to determine, in which of them the constituents unite in the simplest proportion, or one atom with one atom.

Thus the

Protoxide of azote is composed of	14 azote	+	8 oxygen.
Deutoxide of azote	14	+	16
Hyponitrous acid	14	+	24
Nitrous acid	14	+	32
Nitric acid	14	+	40

or the

Protoxide of azote is composed of	40 oxygen	+	70 azote.
Deutoxide of azote	40	+	35
Hyponitrous acid	40	+	23·3
Nitrous acid	40	+	17·5
Nitric acid	40	+	14

If it be supposed that nitric acid is a compound of one atom of oxygen and one of azote; then it is seen, by the last statement of those just given, that nitrous acid will be made to be a compound of one atom of oxygen, and one atom and a fraction of azote; or if the azote be taken at the same number in both these acids, then the latter will be made a compound of one atom of azote, and a fraction of an atom of oxygen. Now neither of these suppositions is tenable, consistently with the nature of an atom.

If it be supposed, that the protoxide of azote is a compound of one atom of azote, and one atom of oxygen; then the deutoxide is either a compound of one atom of oxygen and half an atom of azote, or of two atoms of oxygen and one atom of azote; as will be seen most clearly by the statement last given. Now the last supposition may be held consistently with the atomic theory; and therefore there is nothing in the supposition that the constituents of the protoxide unite atom with atom, which is inconsistent with an atomic composition for the deutoxide. But it is necessary that no atomic inconsistency should exist upon viewing the other compounds of azote and oxygen; otherwise the atomic assumption already made would be untenable. Now it is seen by the first statement, that, without atomic inconsistency, hyponitrous acid may be considered a compound of 1 atom of azote, united to 3 atoms of oxygen; nitrous acid, of 1 atom of azote, united to 4 atoms of oxygen; and nitric acid, of 1 atom of azote united to 5 atoms of oxygen. It may, indeed, be said that the deutoxide of azote is a compound of 1 atom of oxygen, united to 1 atom of azote; and that the protoxide is composed of 1 atom of oxygen united to 2 atoms of azote; and as far as this supposition goes, there would no atomic inconsistency in it. But when the same atomic supposition is attempted to be applied to the other compounds of azote, it will be found entirely to fail; as it will make a resort to a fractional atom unavoidably necessary.

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It is difficult to give a concise rule, for determining when a combination takes place in the simplest proportion, or one atom of one constituent with one atom of the other; but it may be stated in general terms, that the particular combination between any two substances, uniting in several proportions, is the simplest, of either of the constituents of which, the same constituent, in every other compound of the same ingredients, may be some exact multiple.

What has been said is sufficient to enable any one to satisfy himself of the truth or falsity of the atomic theory.

The facts and reasonings, upon which the atomic theory rests, are too diversified to allow a full enumeration of them to be made in this place. All that is intended by the imperfect sketch, which has just been completed of this theory, is to enable the student, by means of the outline given, to test its accuracy, by pursuing the subject in all its ramifications.

This may very easily be done by any one, who will take the trouble of examining any compound already described, the composition of which is ascertained with tolerable accuracy. The numbers in all the analyses, already given, are made to accord with the atomic theory, as far as the results of actual experiments would warrant. The weights of the atoms are all compared with the weight of an atom of hydrogen; which is assumed as unity in conformity with Mr. Dalton's plan. Every analysis, which was found not to accord with any supposition of atomic combination, is distinguished by an asterisk. But in all such cases, the equivalent number of the substance, under which the analysis is given, is assumed; whilst the amount of the body, with which it may combine, is calculated proportionally.

Reasons for having introduced the atomic theory at this stage of the present work.

It may appear strange to the reader, that he is introduced to a knowledge of the atomic theory, for the first time, at a period when the work has considerably progressed; and that he has been studying numbers adjusted in conformity with a theory, about which he should be presumed to know nothing. But the object of this course is easily explained. The student could not, with any prospect of advantage, have been made acquainted with the atomic theory at the very threshold of his inquiries. He is then presumed to know very little of chemical science; and consequently, not to be in possession of the data, without which, it would be impossible for him to understand the subject. But, after he had been made acquainted with these data to a sufficient extent, by pursuing part of the work; it became expedient to bring forward the theory, in order that the remainder might derive every possible advantage from its application.

Nothing as yet has been said of the rise and progress of the theory, which has just been attempted to be described.

Idea of combination by atoms first suggested by Higgins in 1789.

It appears to be generally admitted, that the idea of bodies uniting chemically by particles or atoms, was first suggested by Higgins in 1789. Many facts respecting definite proportions were afterwards ascertained by Dr. J. B. Richter, between the years 1792 and 1802. It was this chemist, who discovered, that, upon the decomposition of neutral salts, the resulting salts preserved a neutral state also; and, further, that whatever quantities of the acids were found to saturate any particular salifiable base, proportionate quantities would saturate every other base; and conversely, whatever quantities of salifiable bases were sufficient to saturate any particular acid, proportionate quantities would saturate every other acid. These facts led very directly to the supposition of atomic combination; but it does not appear that Dr. Richter drew any conclusion from them of this kind.

Dalton, however, may be considered the real author of the atomic theory.

It was reserved for Mr. Dalton to put forth the atomic theory, supported by such evidences as to render it almost universally admitted. This chemist, who may be considered the author of the theory, as early as the year 1802, began to perceive many facts, which led to the supposition of definite proportions, and atomic combination; and, in successive years, the theory has been gradually matured, so that, at the present time, it wears every appearance of truth; and, from its tendency to establish fixed relations between the numbers, expressive of chemical combination, may be justly reckoned one of the most important discoveries yet made in chemistry.

Weights of the atoms of the undecompounded ponderable bodies.

Having thus finished the account of the atomic theory, the reader may be presented, with advantage, with the weights of the atoms of each of the undecompounded ponderable bodies, as far as they have been ascertained.

*Statement of the weight of the Atom of each of the Undecompounded Ponderable Bodies.**

1. Oxygen	8	18. Tellurium	32*	35. Manganese	28*
2. Chlorine	36	19 Potassium	40	36. Cerium	—
3. Iodine	125	20. Sodium	24	37. Uranium	125*
4. Fluorine	—	21. Lithium	10*	38. Zinc	33
5. Azote	14	22. Calcium	21*	39. Lead	104
6. Hydrogen	1	23. Barium	70*	40. Tin	59
7. Carbon	6	24. Strontium	44*	41. Copper	64
8. Boron	—	25. Magnesium	12*	42. Bismuth	71*
9. Phosphorus	12	26. Yttrium	—	43. Mercury	200
10. Sulphur	16	27. Glucinum	—	44. Silver	110
11. Arsenic	47*	28 Aluminum	—	45. Gold	200*
12. Chromium	28*	29. Zirconium	—	46. Platinum	—
13. Molybdenum	48*	30. Thorinum	—	47. Palladium	56*
14. Tungsten	96*	31. Silicum	8*	48. Rhodium	—
15. Columbium	146*	32. Iron	28	49. Iridium	—
16. Selenium	40*	33. Nickel	27	50. Osmium	—
17. Antimony	45*	34. Cobalt	29	51. Titanium	—

* All the numbers in the table cannot be deduced from analyses already given; but they will be confirmed by compositions, which will be laid before the reader during the progress of the work.

The weight of the atom of those substances, whose correlative number is distinguished by an asterisk in the preceding table, is to be considered as approximated only.

Advantages to be gained by recollecting the equivalent numbers of chemical bodies.

As the numbers above given have the same ratio to each other, as the weights of the atoms, which they respectively represent; it must be obvious, that, whenever two bodies unite in the simplest proportion, they unite in the ratio expressed by their equivalent numbers. Hence if the equivalent numbers be recollected, the ratio in which any combination takes place in the simplest manner, must also be known. For example, if it be borne in mind, that the equivalent number for sulphur is 16, and for chlorine 36; then it will be known that if sulphur and chlorine combine in a simple proportion, it is in the ratio of 16 to 36: again, if it be recollected that the equivalent number for oxygen is 8, and that for azote 14, and also that nitric acid is composed of 1 atom of azote combined with 5 atoms of oxygen; then it may be at once deduced, that, in nitric acid, the azote is to the oxygen as 14 to 40.

DIVISION II.

OF COMPOUND PONDERABLE BODIES.

Some compound bodies, already noticed,

MANY of these bodies have been already described, when treating of the different undecompounded bodies. Of course, under this head, those compound ponderable bodies only, not heretofore described, will find a place.

and for what reasons.

It may not be very obvious, why some of these bodies are described under the undecompounded bodies; while others are reserved for this division of the work. Various reasons, however, have operated in determining where different compounds should stand. The chlorides, iodides, sulphurets, phosphurets and carburets, are described under the undecompounded ponderable bodies; because their descriptions are generally short; and by standing near the bodies of which they are formed, the association of the compound with its most important constituent is more direct and better preserved. The alkaline and earthy salifiable bases are reserved for this part of the work; because, they are important in themselves, and require a separate description. On the other hand, the remaining salifiable bases (usually called metallic oxides) are treated of under the metals of which they are formed; because, generally speaking, their individual importance is not very great.

The compound ponderable bodies will be treated of under the four heads of CHAP. I.

Compound ponderable bodies, considered under four heads.

Salifiable Bases.
Acids.
Salts.
Unsalifiable Compounds; and will form the subjects of as many chapters. After the chapter on acids has been completed; the term *acid*, in the chemical sense, will be explained; and some account will be given of the principles of the classification of acids, pursued in the present work. These subjects will be embraced in a separate chapter.

CHAPTER I.

OF SALIFIABLE BASES.

Salifiable bases, divided into three classes.

THE salifiable bases will be divided into the three following classes.

I. Alkaline salifiable bases.
II. Earthy salifiable bases.
III. Salifiable bases, having neither alkaline nor earthy properties.

CLASS I.

ALKALINE SALIFIABLE BASES.

Alkaline salifiable bases enumerated.

The alkaline salifiable bases are:

1. Ammonia,	4. Lithia,	7. Strontian,
2. Potash,	5. Lime,	8. Magnesia.
3. Soda,	6. Barytes,	

They will be treated of, in the order in which they have been enumerated, in the eight following sections.

SECTION I.

OF AMMONIA.

Common names, *Volatile Alkali.—Hartshorn.*

Ammonia; how obtained.

I. AMMONIA may be obtained by exposing a mixture of three parts of quicklime, and one part of hydrochlorate of ammonia (sal ammoniac) in powder, in a retort, to the heat

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of a lamp. A gas is formed, which must be collected over mercury. This gas is ammonia.

Process explained.

II. Hydrochlorate of ammonia is a salt composed of hydrochloric (muriatic) acid, and the substance under description. By being heated with lime, it is decomposed; the hydrochloric acid forms with the latter substance, chloride of calcium and water, while the ammonia is disengaged.

Process pursued by the manufacturer.

III. Ammonia is obtained, by the manufacturer, by the destructive distillation of all animal substances (except fat), which have not suffered spontaneous decomposition. The substances generally employed are refuse bones and the pith of horns. The distilled product is an impure ammonia, partly in a concrete state and partly dissolved in water, containing a portion of carbonic acid and some empyreumatic oil. To be obtained pure, it is first saturated with sulphuric acid, and then converted into hydrochlorate of ammonia by double decomposition with chloride of sodium (common salt). The hydrochlorate is made to yield up its ammonia in the manner just described.

Discovery.

IV. This gas was first obtained in a pure state by Dr. Priestley. Besides the names already given, it formerly had several others; such as *spirit of urine*, because it was obtained by the distillation of urine; and *spirit of sal ammoniac*, because it was sometimes obtained from sal ammoniac.

Properties.

V. Ammonia is a gaseous substance, transparent and colourless like air. Its taste is acrid and hot; and its smell, exceedingly pungent. It changes vegetable blues to green. When exposed to a cold of $-45°$, it assumes the liquid form; but becomes a gas immediately, if the temperature be raised. When passed through a red hot tube it is decomposed.

Spec. grav. 0·590.

VI. It is a very nearly six-tenths as heavy as common air.

It cannot be drawn into the lungs.

VII. Ammoniacal gas is, strictly speaking, unrespirable: when the attempt is made to draw it into the lungs, the glottis closes spasmodically. It does not support combustion: when a lighted candle is let down into it, its flame is extinguished; but, previously to that effect taking place, at the moment of immersion, it is enlarged by being surrounded by another flame of a pale yellow colour, which descends from the top to the bottom of the containing vessel. Ammoniacal gas, although containing a combustible substance, will not burn in atmospheric air; but when expelled from a tube with a narrow orifice, and surrounded by oxygen gas, it burns with a pale yellow flame; water being formed and azote liberated.

Burns under peculiar circumstances only.

Combines with water and forms

VIII. This gas combines very readily with water, and forms the compound called liquid ammonia.

LIQUID AMMONIA.

Water of Ammonia of the Edinburgh College.

1. This combination takes place whenever ammoniacal gas comes in contact with water. The union is attended by an increase of temperature, as well as of the bulk of the water employed. Liquid ammonia.

2. The Edinburgh college directs the following process, for the preparation of the water of ammonia: To two pounds of quicklime, previously slaked by one pound of water, and placed in a retort, add one pound of hydrochlorate of ammonia (sal ammoniac), dissolved in five pounds of water. Shut the mouth of the retort, and mix the substances by agitation. Now distil into a refrigerated receiver, with a gentle heat, until twenty ounces of liquid have been abstracted. Liquid ammonia; how obtained for medical use.

3. The above process agrees with that given for the preparation of pure ammonia; except that the presence of water, in the latter, causes the ammonia to come over combined with that liquid. Its properties.

4. Liquid ammonia is the usual form, in which ammonia is employed by the chemist. When it is heated to the temperature of 130°, the ammonia separates in the form of gas: When exposed to a cold of —46°, it crystallizes. If suddenly cooled to —68°, it assumes the appearance of a thick jelly; having scarcely any smell.

5. Liquid ammonia is capable of dissolving the oxides of silver, copper, iron, tin, nickel, zinc, bismuth and cobalt. It deoxidizes the oxides of mercury, lead and manganese; water being formed, and azotic gas emitted. Dissolves some oxides, and deoxidizes others.

6. Water, when saturated with ammonia, contains 670 times its bulk of the gas, which amounts to about one-third of its weight; and its specific gravity is reduced to ·875. Composition of liquid ammonia.

7. Liquid ammonia is a very powerful stimulant. It is not often given internally, because other preparations for internal use, are preferred. When applied to the skin, it acts powerfully as a rubefacient, and is used with a view to this effect in chronic rheumatism and in paralysis. The ammoniacal gas, which exhales from it, stimulates strongly the nose and eyes. When applied to the nose, it constitutes a very efficacious stimulant in syncope. It is sometimes applied to the eyes in chronic ophthalmia. Medical uses of liquid ammonia.

IX. A mixture of ammoniacal gas with oxygen may be fired by the electric spark. If the oxygen be in excess, part of the ammonia is decomposed, and nitric acid and water are obtained; the former of which combines with the undecomposed portion, and forms nitrate of ammonia. Ammoniacal and oxygen gases, fired by the electric spark.

Effects of being mixed with chlorine.

X. When pure ammonia is mixed with chlorine gas, combustion takes place, and it is partially decomposed. The azote of the decomposed portion is evolved: while its hydrogen combines with the chlorine, so as to form hydrochloric (muriatic) acid; which then unites with the undecomposed portion, and forms hydrochlorate of ammonia (sal ammoniac).

Sulphuret of ammonia.

XI. The sulphuret of ammonia may be formed by causing ammonia to come in contact with sulphur in a state of vapour. Its properties have not been investigated.

XII. Ammonia does not appear capable of combining with the metals. Whenever it appears to dissolve them, it is after having oxidized them at the expense of the water, with which it is combined.

Ammonia combines with oxide of gold, forming fulminating gold:

XIII. Ammonia combines with the oxides of gold, of silver, and of platinum, and forms compounds, called fulminating gold, fulminating silver, and fulminating platinum.

1. *Fulminating gold* may be prepared by dissolving gold in aqua regia, diluting the solution with thrice its weight of water, and adding to it, by degrees, liquid ammonia, as long as any precipitate appears. The precipitate thus obtained must then be washed in pure water, and dried slowly on filtering paper. It is now fulminating gold, or the ammoniuretted oxide of gold. To prevent accidents, the phial, in which it is kept, must not be corked; but its mouth covered with a piece of linen or paper.

2. Fulminating gold is a yellow powder. It has its name from the property of exploding whenever it is violently struck. The cause of this property is the sudden decomposition of the powder. The hydrogen of the ammonia combines with the oxygen of the oxide, forming water; the gold is reduced, and the other constituent of the ammonia, (azote) suddenly assumes the elastic form, and gives rise to the explosion.

with oxide of silver, forming fulminating silver:

1. *Fulminating silver* is formed by allowing liquid ammonia to stand for twelve hours, upon the precipitate formed, in the nitric solution of silver, by lime water. The precipitate must then be separated, and dried in very small portions upon filtering paper. It is now fulminating silver.

2. This powder, even when moist, explodes violently when struck; when dry, the same effect is produced by the least touch. The explanation of its explosion is the same with that given of the same property in fulminating gold.

and with oxide of platinum, forming ful-

1. *Fulminating platinum* is formed by digesting the precipitate, formed in a solution of platinum in aqua regia by hydrosulphuric acid (sulphuretted hydrogen), in nitric acid,

until it is converted into sulphate of platinum: this sulphate, being dissolved in water, is then precipitated by liquid ammonia; the precipitate formed, after being washed, is boiled for some time, with a solution of potash, in a Florence flask; and then separated by the filter. The powder, thus obtained, after being washed and dried, constitutes fulminating platinum.

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2. Fulminating platinum is a brown powder. It does not explode by trituration or percussion, but by exposure to heat, very violently.

Ammonia, composed of hydrogen and azote.

XIV. Ammonia is composed of

Hydrogen	3	—three atoms.
Azote	14	—one atom.
	—	

Giving 17 for the number representing the atom of this alkaline base.

Discovery of its composition.

XV. The nature of ammonía was gradually developed by the labours of Scheele, Priestley, and Berthollet. Scheele discovered, that when ammonia is decomposed by certain metallic oxides; the oxides are reduced, the gas disappears, and a quantity of azote is found in its place. Priestley ascertained, that, when heat is applied to the peroxides of lead and mercury, confined in ammoniacal gas; these oxides are reduced, water is formed, and, in the place of the ammonia, a quantity of azote is found. The results, obtained by these chemists, led to the conclusion, that ammonia is a compound of azote and hydrogen; an opinion, afterwards amply confirmed by Berthollet.

Ammonia, supposed to be a metallic oxide.

XVI. A galvanic experiment, made by Berzelius and Pontin, gave reason to believe, at one time, that ammonia was composed of a metallic radical, united to oxygen. These chemists found, upon negatively electrifying mercury, in contact with a solution of ammonia, that a globule was produced, having the metallic lustre, and a volume, five times as great as the mercury employed. The conclusion, which they drew from the phenomena of this experiment, was, that this globule is an amalgam formed with some metal, previously unknown, and probably the radical of ammonia. The experiment of Berzelius and Pontin was repeated, with the same result, by Davy; who was inclined to coincide, in opinion, with these chemists, with regard to the nature of the globule.

The conclusions, drawn from the experiments of Berzelius and Pontin, going to establish a perfect analogy between all the salifiable bases, were received, rather favourably, by the chemical world. The subsequent experiments, however, of Gay-Lussac and Thenard, made with great care,

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induced these chemists to conclude, that the supposed amalgam is, in reality, a compound of mercury and ammonia; and, at present, the general impression is very much in favour of their opinion.

SECTION II.

OF POTASH.

Syn. *Pure Kali.—Caustic Vegetable Alkali.*

Potash; how obtained pure.

I. The only method to obtain potash, absolutely pure, is to expose the peroxide of potassium to a sufficient heat, to drive off the second dose of oxygen, which it contains. In this way, perfectly pure potash was first obtained, by Sir H. Davy. For the common purposes of the chemist, however, the hydrate* of potash, or potash pure in every respect, except that of containing a portion of water, in the solid form, is sufficiently pure; and, when potash is spoken of, in any part of this volume, it is the hydrate, which is meant; unless otherwise particularly specified.

How obtained in the state of hydrate.

II. Berthollet's method for obtaining potash, is the following: Mix any quantity of the pearl-ash of commerce, with twice its weight of lime, and ten times its weight of water. Put the mixture in a close glass vessel; and let it stand for forty-eight hours, shaking it occasionally. Filter the liquid, and then boil it rapidly, in a silver vessel; until upon cooling, it may be able to assume the consistence of honey. Now add to it, a quantity of alcohol (spirit of wine) equal to one-third of the pearl-ash, originally employed. After having shaken the whole, boil it for a few minutes, and then pour it into a glass vessel; which must then be tightly corked. By degrees, the mixture separates into two portions; the upper portion must be decanted into a silver basin, and evaporated rapidly, until a crust form upon its surface. It is then to be poured into a porcelain vessel, and allowed to concrete. The substance, thus obtained, is potash.

The last process explained.

III. The pearl-ash of commerce is an impure carbonate of potash. Now lime has a stronger affinity for carbonic acid, than potash has; and, therefore, in the process just given, it separates the greater part of this acid from the pearl-ash. The lime becomes converted into carbonate of

* Hydrates are solid compounds, which contain combined water.

lime (chalk), which is insoluble; and the pearl-ash, into a mixture of pure potash, and undecomposed carbonate. Filtration removes the carbonate of lime. Alcohol possesses the property of dissolving potash, but does not act upon its carbonate. The treatment, therefore, of the filtered liquid, with alcohol, results in the formation of an alcoholic solution of potash, free from admixture of the carbonate. This solution swims on the surface, and is separated by being decanted. The rapid evaporation, to which it is afterwards subjected, drives off the alcohol, and leaves the potash pure.

Preparation of potash for medical use.

IV. The Edinburgh college directs the following process for obtaining potash: Evaporate the solution of potash,* until ebullition cease, and the liquid flows like oil. When this happens, the water of the solution will have been driven off. Now pour the liquid on a smooth iron plate; and, before it hardens, divide it into small pieces, and keep them in well stopped phials. The precaution, last mentioned, is necessary, to prevent the absorption of carbonic acid.

Properties of potash.

V. Potash, obtained by either of the processes last described, is a solid white substance, having an unctuous feel, and an extremely acrid taste. Its smell resembles that, which is perceived during the slaking of lime. It changes vegetable blues to green. It is deliquescent in the air. After being exposed to a red heat; it still contains water, to the amount nearly of 16 per cent.

Spec. grav. 1·70.

VI. It is about one and three-fourth times as heavy as water.

Potash forms, with water, liquid potash.

VII. Potash dissolves readily in water, and forms a solution, which will be called liquid potash.

LIQUID POTASH.

Water of Potash, of the Edinburgh college—commonly called *Caustic Lie.*

Liquid potash; how obtained for medical use.

1. The process of the Edinburgh college, for preparing this solution, is the following: Mix eight ounces of lime with twenty-eight ounces of warm water: the lime will slake violently, and cause the ebullition of the mixture. As soon as this is over, add instantly six ounces of carbonate of potash (salt of tartar); mix the whole, and let it stand to cool, in a covered vessel: the carbonic acid becomes transferred to the lime, which is thereby converted into carbonate of lime; while the pure potash remains in solution. After the mixture has cooled, agitate it well to mix its

* Solution of potash is an officinal preparation, to be mentioned presently.

several parts; and then filter it gradually, from a covered glass funnel, whose throat is obstructed by a piece of clean linen, and whose tube is inserted into a glass vessel, to receive the filtered product. As soon as the liquid should cease to drop; add, cautiously, to the mixture in the funnel, a few ounces of water, in such a manner, as that the latter may swim on the surface of the former. This addition causes the liquid again to drop; and similar ones are to be repeated, until three pounds of the filtered liquid are procured; which quantity will be obtained after the lapse of two or three days. The object of the filtration is to separate the insoluble carbonate of lime, which remains upon the funnel; nothing passing through but the solution of the potash. Water is directed to be added occasionally, until the filtered liquid shall amount to three pounds; in order that the solution, being intended for medical use, may always be prepared of the same strength. The solution must be kept in well stopped bottles, in order to guard against the absorption of carbonic acid.

Properties of liquid potash.

2. Liquid potash is transparent, and has the consistency of oil. It is in this form, that potash is usually employed by chemists. When it is a saturated solution, it contains about two-thirds of its weight of potash.

Its medical uses.

3. Liquid potash has enjoyed, at various times, considerable reputation, as a solvent of calculi. It has, undoubtedly, relieved many cases of stone; but, in many others, it has totally failed. This difference, in its effects, is explained, by supposing the existence of a different kind of calculus, in the various cases, in which it has been used. Modern chemistry has thrown great light on the nature of urinary concretions. It has ascertained them to be of a great many different kinds. Some are soluble in potash, and in soda; while others dissolve only in the acids. Now, it appears, that the solution of potash is best suited to the former kind; which are found to consist of a certain acid, called by chemists uric acid, either alone, or combined with ammonia. To ascertain the nature of the calculus, which may exist in any particular case, it is necessary to subject the urine to a chemical examination.

When it is determined to use the solution of potash, in a case of calculus, it must be ordered in a very diluted state. Besides its use by the mouth, it has been proposed to inject the solution into the bladder, in cases to which an alkaline solvent may be suited. When this is done, the bladder must be evacuated, and washed out with tepid water. The solution, made so dilute as to admit of being held in the mouth without uneasiness, is then injected into the bladder, and

allowed to remain there for half an hour. After it is evacuated, it is to be tested for the presence of calculous matter in solution.

CHAP. I.

VIII. Potash, when not in the state of hydrate, may be made to combine with an additional dose of oxygen. It is thus converted into peroxide of potassium.

Potash combines with oxygen;

IX. Dr. Thomson has recently ascertained, that potash is capable of forming a chloride. This chemist succeeded, in obtaining it, by double decomposition, from a salt of potash, and chloride of lime. The latter chloride, he found, to constitute the principal part of Mr. Tennant's bleaching salt.* If potash, however, be heated to redness in chlorine gas; chloride of potassium, and not chloride of potash, is formed; oxygen being at the same time evolved. Potash suffers a similar decomposition, when heated in contact with iodine.

and with chlorine.

X. Potash combines, in one proportion, with sulphur; and forms sulphuret of potash.

Sulphuret of potash;

1. Sulphuret of potash, formerly called liver of sulphur, may be formed, by fusing together, two parts of carbonate of potash (salt of tartar) and one part of sulphur. The carbonate becomes decomposed; the carbonic acid is liberated, while the potash combines with the sulphur.

how formed.

2. Sulphuret of potash is a hard and brittle substance, of a liver-brown colour. It has a vitreous fracture. Its taste is acrid, caustic, and bitter. Its smell resembles that of sublimed sulphur. It deliquesces, and suffers decomposition, in the air. It is very fusible. It has not hitherto been analyzed.

Its properties.

XI. Potash is incapable of uniting with the metals; but, when in a state of solution, it is capable of oxidizing several of them. These metals are zinc, iron, tin, and osmium. It is capable of dissolving the oxides of the following metals; namely, arsenic, molybdenum, tungsten, antimony, tellurium, nickel, cobalt, manganese, zinc, lead, and tin.

Potash, in solution, oxidizes some metals.

XII. Potash is composed of

Composition of potash.

Potassium	40—one atom.
Oxygen	8—one atom.

Giving 48 for the number representing the weight of its atom.

XIII. Potash decomposes, almost instantaneously, animal substances of all kinds. This property makes it useful to the surgeon, for the purpose of destroying fungous flesh, or excrescences; and for opening abscesses. It is from this application of it, that it is called, in common language, caustic.

Uses to the surgeon.

* Annals of Philosophy (Mar. 1819.) p. 185.

SECTION III.

OF SODA.

Common names, *Caustic Fossil Alkali.—Caustic Mineral Alkali.*

Soda; how obtained pure.

I. SODA, absolutely pure, was first obtained by Sir H. Davy, by burning sodium in a quantity of oxygen gas, just sufficient to convert it into soda. When thus prepared, it has a grey colour, and presents, when broken, the vitreous fracture. For fusion, it requires a strong red heat. When water is added to it, it becomes solidified; and the soda is converted into a hydrate. When the word soda is used, in chemical descriptions, it is this hydrate which is always meant, unless otherwise specified.

How obtained in the state of hydrate.

II. The best method for obtaining soda, pure in every other respect than that of containing water, is to decompose the soda of commerce, commonly called barilla, which is a carbonate of soda, by means of lime; and afterwards to treat the resulting mass with alcohol. The manipulations of the process, and its explanation, are exactly similar to those given, when describing the preparation of potash.

Sources of soda in nature.

III. Soda is obtained from several different sources in nature. It may be extracted from common salt; which is a compound of sodium, the radical of soda, and chlorine. It is found, in large quantities, combined with carbonic acid, in Egypt, and in several other parts of the world. The ashes of many sea plants, especially of those belonging to the genus salsola, yield it in considerable abundance.

IV. Soda was confounded with potash, to which it bears considerable resemblance, until Du Hamel, in 1736, pointed out its distinguishing properties. The conclusions of Du Hamel were afterwards confirmed by Margraff.

Properties of soda.

V. Soda is a greyish white solid; agreeing exactly with potash, in taste, smell, and the action which it exerts upon animal substances. It changes vegetable blues to green. It is readily soluble in water. When exposed to the air, it absorbs moisture and carbonic acid; assumes, at first, the consistence of paste; but, afterwards, becomes dry, and crumbles into powder. Under similar circumstances, potash would liquefy. The different manner, in which exposure to air affects potash and soda, affords a very obvious criterion for distinguishing these alkaline bodies.

Spec. grav. 1·33.

VI. Soda is about one and one-third times as heavy as water. It is, therefore, considerably lighter than potash.

Soda combines with oxygen;

VII. Soda is capable of combining with an additional dose of oxygen; whereby it is converted into peroxide of

sodium. This oxide has already been described under the head of sodium. CHAP. I.

VIII. Soda may be made to form a chloride, by double decomposition, between a salt of soda, and chloride of lime. This fact has been lately ascertained by Dr. Thomson.* When, however, soda is heated in chlorine gas, it is decomposed, and chloride of sodium (common salt) becomes formed. Soda undergoes a similar decomposition, when heated in contact with iodine. and with chlorine.

IX. Soda is composed of Composition of soda.

Sodium	24—one atom.
Oxygen	8—one atom.

Giving 32 for the number representing the weight of its atom.

X. Soda enters, as a constituent, into many important chemical medicines. Its medical properties will be noticed hereafter, as modified in these combinations. Soda, a constituent in a number of medicines.

SECTION IV.

OF LITHIA.†

I. LITHIA is an alkaline salifiable base, which has been lately discovered by Mr. Arfwedson of Sweden. It occurs to the amount of five or six per cent. associated with alumina and silica, in the mineral called pelatile, where it had been previously mistaken for potash. It is present also, in triphane, in the proportion of eight or nine per cent. associated with alumina, silica and oxide of iron; and it constitutes about four parts, in the hundred, of green tourmaline (crystallized lepidolite) where it is present along with alumina, silica, boracic acid, and the oxides of iron and of manganese. Minerals which furnish lithia.

II. It was discovered in consequence of its very high neutralizing power. When saturated with an acid, in the course of the analysis of petalite by Arfwedson; the calculated amount of salifiable base present, under the supposition that it was either potash or soda, always produced a gain, which was too great to be attributed to common sources of error. The investigation of the causes of this gain resulted in the discovery of lithia.

* Annals of Philosophy (Mar. 1819.) p. 185.

† From λίθειος, stony; because this alkaline base is furnished exclusively by the mineral kingdom; whereas potash and soda are not.

and is converted into chloride of calcium, (dry muriate of lime).* Lime is capable of forming an iodide also.

Phosphuret of lime.

IX. Phosphuret of lime may be obtained by the following process: Put at the bottom of a glass tube, closed at one end, one part of phosphorus; and holding it horizontally, introduce into it, five parts of lime, in small lumps, so as to be within about two inches of the phosphorus. Put the tube across some burning coals, in such a manner, as that the lime may be brought to a red heat, while the phosphorus is comparatively cold. As soon as this is accomplished, move the tube along the coals, so as to expose the phosphorus to the heat; by which it will be converted into vapour, and, in this state, combine with the lime. During the combination, the mass becomes of a glowing red heat, and a quantity of hydroguret of phosphorus (phosphuretted hydrogen) is emitted; which takes fire as soon as it comes in contact with the atmosphere. This phosphuret has a deep brown colour. It falls to pieces when exposed to the air. It is not soluble in water; but, when thrown into this liquid, it causes its decomposition, and hydroguret of phosphorus is evolved. It has not been analyzed.

Sulphuret.

X. Sulphuret of lime may be formed by heating its constituents together in a crucible. It has a reddish colour, which becomes greenish yellow, when exposed to the air or moistened with water. It has not been analyzed.

Lime, with potash, forms a caustic.

XI. Lime, combined with potash, forms the officinal preparation, commonly called *milder common caustic*.

1. The Edinburgh college directs the following process for preparing this compound: Evaporate liquid potash (solution of potash) in a covered vessel, to about one-third. After being thus concentrated, add to it as much hydrate of lime (new slaked lime), as will bring it to the consistency of a pretty solid pap. The mass constitutes the caustic in question. It must be preserved in bottles, well closed from the air.

Its uses to the surgeon.

2. This compound of lime with potash is the caustic usually employed by surgeons for opening abscesses, for making issues, and, indeed, for most of the purposes, for which a caustic is required.

Composition of lime.

XII. Lime, as the reader has already been informed, is an oxide of a peculiar metal, called calcium. It is composed of

Calcium	21—one atom.
Oxygen	8—one atom.
	—
Giving	29 for the number representing its atom.

* Annals of Philosophy (Mar. 1819) p. 182.

XIII. Lime is of very great importance in the arts. It constitutes the principal ingredient in mortar. The best proportions for this cement are

Lime, the principal ingredient in mortar.

Fine sand	3	parts.
Coarser sand	4	
Lime, recently slaked,	1	

Water, a sufficiency only to mix the ingredients.

Mortar owes its property of becoming hard to the absorption of carbonic acid, as well as to the solidification of a portion of water. By means of this property, as well as that of adhering strongly to brick or stone; it is capable of joining these substances together, as firmly as if they had been originally in one piece.

The addition of a little clay to this cement, gives it the property of hardening under water. Certain lime stones contain a proportion of clay; and these, when burnt, furnish a very proper lime for water mortar. The best water mortar, however, is composed of lime, and puzzolano, a volcanic sand found in Italy.

Is corrosive.

XIV. Lime acts with considerable energy, as a corrosive, upon the animal fibre. Its principal medical properties, when in solution, have already been mentioned, and need not be repeated here.

SECTION VI.

OF BARYTES.*

Barytes; how obtained pure.

I. Barytes may be obtained pure by the following process: Expose a mixture, in a crucible, of eight parts, in powder, of ponderous spar (sulphate of barytes), and one part of charcoal powder, for several hours to a red heat: by this treatment, the sulphate of barytes becomes converted into a sulphuret. Dissolve the sulphuret in water, and add nitric acid to the solution, as long as any precipitate appears: this acid combines with the barytes, and throws down the sulphur. Separate the sulphur by the filter; and evaporate the clear liquid, until it form crystals of nitrate of barytes. Expose the crystals, thus obtained, to a strong heat, gradually increased: the nitric acid will be driven off, and the barytes left pure.

How found.

II. Barytes occurs native, only in combination with sul-

* From βαρύς, heavy; on account of the unusual weight of the spar, from which it was first obtained.

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phuric or carbonic acid, forming sulphate or carbonate of barytes.

III. It was discovered by Scheele, in 1774.

Its properties.

IV. Barytes is a porous substance, of a greyish-white colour. It is easily reduced to powder. It has an acrid, urinous taste, more caustic than that of lime. It possesses no perceptible smell. When exposed to the air, it attracts moisture, swells, evolves heat, and is converted into a hydrate. If the exposure be long continued, it gradually attracts carbonic acid, and loses its causticity. It is capable of decomposing animal substances; but not with as much energy as potash or soda.

V. Barytes is about four times as heavy as water.

Combines with water, as a hydrate and as a liquid.

VI. Barytes combines with water in two forms: in the solid form, as a hydrate; and in the liquid form. The hydrate may be formed by slaking barytes; that is, by sprinkling it with water, as long as this liquid is absorbed. The cold solution of barytes, when saturated, contains not more than one-twentieth of its weight of barytes; but the hot solution is capable of containing more than half its weight. The hot solution, as it cools, lets fall the barytes, in the form of transparent colourless crystals. These crystals, when exposed to the heat of boiling water, undergo the *watery fusion*, as it is called; that is, are dissolved in the water, which, at a lower temperature, existed, combined with them, in the solid form. If the heat be, afterwards, gradually increased, this water is driven off, and the barytes becomes dry. When the temperature arrives at the point of redness, the dry mass melts, and flows like oil. But when barytes is obtained by decomposing the nitrate, it is perfectly infusible in the most intense heat, that can be raised. This infusibility of barytes, as obtained from the nitrate, is supposed to be owing to the absence of water.

Combines also with oxygen; and with chlorine.

VII. Barytes is capable of combining with oxygen. This compound has been already noticed as peroxide of barium.

VIII. Barytes is capable of forming a chloride, as Dr. Thomson first ascertained. This chemist obtained it, by double decomposition, between a salt of barytes and chloride of lime.* When, however, chlorine gas is passed over red hot barytes; the latter is decomposed, oxygen is evolved, and the resulting compound is chloride of barium.

Phosphuret of barytes.

IX. Phosphuret of barytes may be formed by heating its ingredients together, in a tube, closed at one end. A rapid combination takes place, and the phosphuret is formed. It is a brilliant, very fusible substance of a dark brown colour.

* Annals of Philosophy, (Mar. 1819) p. 185.

When thrown into water, it decomposes this liquid; the hydrogen of which, combining with part of the phosphorus, forms hydroguret of phosphorus, which inflames as soon as it comes in contact with the air; while the oxygen of the water, combining with the remaining phosphorus, forms phosphoric acid. — Chap. I.

X. Sulphuret of barytes may be formed, by melting its constituents together in a crucible. A red heat is required for the fusion. It has a reddish-yellow colour, and no smell. When exposed to the air, or dissolved in water, it becomes decomposed; and hydrosulphuric acid (sulphuretted hydrogen) is evolved. — Sulphuret.

XI. Barytes, as has been already mentioned, is an oxide of a peculiar metal, which has been called barium. Its exact composition has not been ascertained by any direct experiments. — Constituents of barytes.

XII. Barytes acts as a very violent poison on the human system. The effects of the chloride of barium have already been noticed; and the cases, in which it has been used as a medicine, pointed out. It does not appear, however, that any compound has been used medicinally, in which barytes exists ready formed. — Barytes, a poison.

XIII. In cases of poisoning by barytes, Orfila recommends the swallowing of large quantities of some sulphate; such as of sulphate of soda (Glauber's salt) or of sulphate of magnesia (Epsom salt). In this way, he proposes to form, in the stomach, a sulphate of barytes; which, from its great insolubility, may be considered as nearly inert. Afterwards, in case vomiting does not take place spontaneously, he recommends that it should be encouraged by the usual methods.* — Its antidote.

SECTION VII.

OF STRONTIAN.†

I. Strontian may be obtained pure by the following process: Dissolve the mineral called strontianite (carbonate of strontian) in nitric acid: this acid will displace the carbonic acid, and dissolve the strontian. Evaporate the nitric solution, until it form crystals of nitrate of strontian; and — Strontian; how obtained pure.

* Nancrede's abridgment of Orfila on Poisons, p. 170.

† So called, from having been first found in the lead mine of *Strontian*, in Argyleshire, Scotland.

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expose them to a red heat: the nitric acid will thereby be driven off, and the strontian left pure.

How found.

II. Strontian has been found, heretofore, only as a sulphate, or a carbonate. It was discovered, in 1791, by Dr. Hope.

Properties of strontian.

III. Strontian is a porous substance, of a greyish-white colour, and possessing an acrid taste. It converts vegetable blues to green. It attracts moisture and carbonic acid. It is not poisonous; and acts but feebly upon animal substances. It tinges flame of a lively purple colour. It resembles barytes in many respects; but it may be distinguished from the latter, by the colour, with which it tinges flame; and by its salts, which are very different from those of barytes.

IV. Strontian is between three and four times as heavy as water.

Strontian forms a hydrate and a solution.

V. Like the other alkaline salifiable bases, strontian is capable of existing in two states of combination with water. The hydrate may be formed, by sprinkling strontian with water. The strontian swells, becomes hot, and falls to powder, exactly as barytes does. The cold solution, when saturated, contains not more than $\frac{1}{163}$rd part of its weight of strontian. Barytes is, therefore, much more soluble than strontian. The hot solution, however, contains a much larger quantity; and, as it cools, it lets fall the strontian in the form of crystals. Crystallized strontian is fusible at a red heat; but, when obtained from the nitrate, it is infusible. The fusibility of the crystals is supposed to be owing to the presence of water.

May be superoxidized

VI. Thenard has recently ascertained, that strontian is capable of being peroxidized. This combination has already been noticed, under the name of peroxide of strontium.

Forms a chloride.

VII. Chloride of strontian may be formed, by double decomposition, from a salt of strontian, and chloride of lime, as Dr. Thomson has lately ascertained.* When, however, chlorine gas is passed over strontian, at a red heat, the latter is decomposed, oxygen is evolved, and chloride of strontium is formed. Iodine combines with strontian, always without decomposition.

Composition of strontian.

VIII. Strontian, as the reader has already been informed, is an oxide of a peculiar metal, which has been called strontium. Its exact composition has not, as yet, been ascertained by any direct experiment.

IX. Strontian has no uses, either in medicine, or the arts.

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* Annals of Philosophy, (Mar. 1819) p. 185.

SECTION VIII.

OF MAGNESIA.

(Usually called, *Calcined Magnesia.*)

I. MAGNESIA may be obtained pure, by dissolving sulphate of magnesia (Epsom salt) in water, and precipitating the solution by potash. The potash combines with the sulphuric acid, and remains in solution; while the magnesia, being insoluble, falls in the form of powder. Magnesia; how obtained pure.

II. Magnesia is obtained, by the apothecaries, by exposing, in a crucible, carbonate of magnesia (common magnesia) for several hours, to a red heat. The carbonic acid is thereby driven off, and the magnesia, left pure. From the nature of this process, magnesia is very frequently called *calcined magnesia.* How obtained for medical use.

III. Uncombined magnesia has been found at Hoboken, in New-Jersey; but it is a very rare mineral. The stones, which contain magnesia, have certain external characters, by which they may be known. They have an unctuous feel, a greenish colour, a fibrous texture, and a silky lustre. The salts of magnesia, which occur native, are the sulphate, carbonate, and borate. How found.

IV. Magnesia was first introduced into medicine, at the beginning of the last century. Its preparation was kept secret; but, notwithstanding, it was discovered, that it was present in the lixivium, remaining after the preparation of nitrate of potash (nitre). It was, however, confounded with lime, by most chemists, until Dr. Black published his experiments upon it, in 1755. The conclusions of this chemist were confirmed, and extended, by Margraff, in 1759; and by Bergman, in 1775. Discovery. Chemical nature, ascertained by Black.

V. Magnesia is a very soft, white, insoluble powder; possessing very little taste, and not the least smell. It converts delicate vegetable blues to green. When exposed to the air, it absorbs moisture, and carbonic acid; but this absorption goes on exceedingly slow. Its properties.

VI. Magnesia is about two and one-third times as heavy as water. It is infusible, when exposed to the strongest heat, which can be raised in a furnace. But, by subjecting it to the heat, produced by the combustion of a stream of oxygen and hydrogen gases, Dr. Clarke succeeded, with great difficulty, in fusing it into a white enamel. Spec. grav. 2·3.

VII. Magnesia is decomposed, at a red heat, by chlorine; and its metallic radical magnesium becomes converted Is decomposed by chlorine.

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into a chloride. It combines with iodine, however, without decomposition.

Sulphuret of magnesia.

VIII. Phosphuret of magnesia has never been formed. But the sulphuret may be obtained by heating gently, in a crucible, one part of sulphur, and two parts of magnesia. It is in the form of a yellow powder, slightly agglutinating. When thrown into water, it causes the evolution of a small quantity of hydrosulphuric acid (sulphuretted hydrogen).

Composition of magnesia.

IX. Magnesia, like all the other alkaline salifiable bases, is a metallic oxide. But the proportion, in which its constituents unite, has not been experimentally ascertained.

Its medical uses.

X. Magnesia is a very valuable medicine. Its effects are those of an antacid and gentle aperient. For removing acidity of the stomach, it acts more promptly, and with less inconvenience, than carbonate of magnesia (common magnesia).

The class of alkaline salifiable bases, characterized.

Having finished the account of the alkaline salifiable bases; it is now proper to inform the reader, what properties, possessed in common by these bodies, constitute the basis of their arrangement into one class. The usual division of the salifiable bases, is into alkalies, alkaline earths, earths, and metallic oxides. Now, instead of the two first of these classes, the class of alkaline salifiable bases has been substituted. Barytes and lime do not stand well, separated from potash and soda; for they possess the distinctive properties of the latter, although in a less degree. The same remark, with very little variation, will apply to strontian. Magnesia appears to be on the line, between alkaline and earthy salifiable bases; but, having the power of changing some vegetable blues to green, it has been associated with the former.

So that the common property, possessed by the alkaline salifiable bases, is that of changing vegetable blues to green. Besides this property, these bodies have, nearly all, an acrid taste, and act as a caustic upon the skin.

CLASS II.

EARTHY SALIFIABLE BASES.

Earthy salifiable bases, enumerated.

The earthy salifiable bases are the following bodies:

1. Yttria.	3. Alumina.	5. Thorina.
2. Glucina.	4. Zirconia.	6. Silica.

They will be described, in the order in which they have been enumerated, in the following sections.

SECTION I.

OF YTTRIA.*

Yttria; how obtained pure.

I. YTTRIA may be obtained from the mineral, called gadolinite, which is a compound of this salifiable base and silica, combined with the protoxides of cerium and of iron, by the following process: Digest the mineral in aqua regia, as long as any thing is dissolved; and evaporate the solution obtained, nearly to dryness. Then filter it, and dilute it with a considerable quantity of water: by these measures, the silica is separated. Evaporate the liquid, as it now stands, to dryness; heat the dry mass to redness, and afterwards redissolve it in water, and filter the solution formed. To this second solution, add liquid ammonia: a powder immediately falls, which is composed of oxide of cerium, and yttria. Dissolve this precipitate, after having been heated to redness, in nitric acid; and evaporate the solution to dryness, in order to remove any excess of the acid. Dissolve the dry mass in 150 times its weight of water, and add crystals of sulphate of potash to the solution: after the lapse of a few hours, as the crystals gradually dissolve, the oxide of cerium precipitates, in the form of a white powder. Separate the oxide of cerium, by the filter; and add, to the clear solution, liquid ammonia. This addition throws down a powder; which, after being separated, washed, and heated to redness, is pure yttria.

Minerals, which afford yttria.

II. Besides in gadolinite, yttria has been found, in the mineral called yttrocerite, associated with lime, thorina, oxide of cerium, and hydrofluoric (fluoric) acid; and in yttrotantalite, in combination with columbium.

III. Yttria was discovered, in 1794, by Gadolin.

Properties of yttria.

IV. Yttria is in the form of a fine, white insoluble powder, destitute of taste, or smell. It produces no change upon vegetable blues. It is insoluble in alcohol, or in potash or soda; but it dissolves in the carbonates of these alkaline bases.

Spec. grav. 4·842.

V. It is nearly five times as heavy as water. It is the heaviest of the earthy salifiable bases.

Composition.

VI. Yttria, as has already been mentioned, is a compound of a peculiar metal, which has been called yttrium, and oxygen. But the exact proportion, in which its constituents unite, has not been ascertained.

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* From Ytterby, the name of a quarry in Sweden; where the mineral, from which yttria was first obtained, was found.

SECTION II.

OF GLUCINA.*

Glucina; how obtained pure.

I. GLUCINA may be obtained from the beryl or the emerald, in which it is combined, principally, with silica and alumina, by the following process: Reduce the stone to powder, and fuse it with three times its weight of potash. After the mass has been diluted with water, dissolve it in hydrochloric (muriatic) acid, and evaporate the solution formed to dryness. Treat the dry mass with a large quantity of water, and throw the whole upon a filter: the glucina, and alumina, in the state of solution in hydrochloric acid, pass through; while the silica, which constitutes more than half the stone, remains behind, retained by the filter. To the clear solution, thus obtained, add carbonate of potash (salt of tartar), as long as this salt produces any precipitate: this reagent will throw down the glucina and alumina, in a state of mixture. Dissolve the precipitate thus obtained, after being washed, in sulphuric acid; add to the solution formed, sulphate of potash; and then evaporate it to a proper consistency, and let it stand to crystallize: crystals of alum will form, which will contain the whole of the alumina. Separate the crystals from the solution; and, to the remaining liquid, add a solution of carbonate of ammonia, in excess. Then filter the whole, and boil it for some time. A powder gradually falls, which consists of glucina.

In what minerals found.

II. Glucina has been found, heretofore, only in the beryl, and the emerald. The beryl is found, particularly, in Siberia; the emerald comes chiefly from Peru.

III. Glucina was discovered, in 1798, by Vauquelin.

Its properties.

IV. Glucina is in the form of a soft, light, white powder, destitute of taste, or smell. It is insoluble in water, or alcohol; but dissolves in solutions of potash or soda.

Spec. grav. 2·976.

V. It is very nearly three times as heavy as water.

Composition.

VI. Glucina is an oxide of a peculiar metal, which has been named glucinum. Its exact composition, however, is not known.

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* From γλυκὺς, sweet; on account of the sweet taste of the salts, which it forms.

SECTION III.

OF ALUMINA.*

Common names, *Argil*—*Pure Clay*.

I. ALUMINA may be obtained by the following process: Dissolve alum, which is a compound, principally, of sulphuric acid and alumina, in water; and add to the solution, liquid ammonia, as long as any precipitate appears: the greater part of the sulphuric acid, present in the alum, combines with the ammonia, and remains in solution; while a small remainder of it falls in combination with the alumina. Wash the precipitate, thus obtained, in a large quantity of water; and then heat it strongly in a platinum crucible: the small portion of sulphuric acid present is thereby driven off, and the alumina, obtained pure. *Alumina; how obtained pure.*

II. Alumina exists very abundantly native. It constitutes a large amount in all clays, and exists in a great number of minerals. *Exists in clays.*

III. The discovery of alumina, in a pure state, is very much connected with the investigations, made by chemists, into the nature of alum. This latter substance was early known to contain sulphuric acid, and an earth. This earth was supposed to be lime, by Stahl and Neumann. This supposition was proved to be incorrect, in 1728, by Geoffroy, junior; who identified it with the earth, which exists so abundantly in clay. In 1754, Margraff confirmed the conclusions of Geoffroy, obtained the earth in tolerable purity, and described its peculiar properties. Since that time, its nature has been fully investigated by Macquer, Bergman, Scheele, and Saussure, junior. *Account of its discovery.*

IV. Alumina is a fine white powder, destitute of taste or smell. It adheres strongly, when applied to the tongue. It is insoluble in water; but dissolves readily in solutions of potash or of soda. When exposed to heat, it suffers contraction. At low temperatures, this contraction is probably owing to the dissipation of moisture; but, at high ones, it takes place also, without losing any sensible weight. In the latter case, the increase of density may be accounted for by supposing a more intimate union of the particles of the alumina. *Properties of alumina.*

V. Alumina is about twice as heavy as water. When

* From *alumen*, the Latin for alum, the substance from which it was first obtained in a state of purity; so called by Morveau.

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exposed to the violent heat, produced by the combustion of charcoal, by means of a stream of oxygen gas; it undergoes the commencement of fusion, and is converted into a very hard, semi-transparent enamel.

Hydrate of alumina.

VI. Alumina combines with water, in the form of a hydrate. It is always in this state, when precipitated from solution in acids. In the state of dry hydrate, it is capable of absorbing, and retaining, about two and a half times its bulk of water. It exists, in the state of hydrate, in the mineral called wavellite.

VII. Alumina, in combination with peroxide of iron, forms the yellow paint, called yellow ochre.

VIII. When alumina is heated, with either potash or soda; a loose mass is formed, destitute of transparency. When dissolved in solutions of these alkaline bases, it may be precipitated from them, by means of an acid. Alumina is usually obtained, in a state of purity, by this method.

Composition of alumina.

IX. Alumina is a compound, as the reader has already been informed, of oxygen, and a peculiar metal, which has been named aluminum. But the proportion, in which its constituents are combined, has not been correctly ascertained.

X. Alumina constitutes the chief material in China and stone-ware of all kinds. In dyeing, and in calico-printing, it is of indispensable utility.

SECTION IV.

OF ZIRCONIA.*

Zirconia; how obtained pure.

I. Zirconia may be obtained from the zircon, or the hyacinth, both of which minerals are composed almost entirely of zirconia and silica, by the following process: Fuse the pulverized stone, in a crucible, with three times its weight of potash. Wash off the potash, by means of water; and treat the residue with hydrochloric (muriatic) acid, as long as this acid dissolves any thing: the hydrochloric acid will dissolve the zirconia, and leave the silica untouched. But, lest the hydrochloric solution should contain some silica, boil it for some time; whereby any of this earthy base, which may be present, will fall in a state of powder. After having, in this way, freed the acid solution

* From *zircon*, the name of the stone, from which this salifiable base was first obtained.

of the zirconia, from silica; add to it liquid potash: the potash instantly separates the acid, with which it remains in solution; while the zirconia, in a pure state, precipitates in the form of a powder. Chap. I.

II. Zirconia has been, heretofore, found only in two minerals; the zircon and the hyacinth. The former usually comes from Ceylon; the latter is found in the same island, and also in France, and other parts of Europe. It was discovered, in 1789, by Klaproth. In what minerals found.

III. Zirconia is in the form of a fine powder, of a white colour, and harsh feel. It is destitute of taste or smell. It produces no effect upon vegetable blues. It is insoluble in water, alcohol, or in solutions of potash or of soda; but dissolves in solutions of the carbonates of these alkaline bases. Its properties.

IV. Zirconia is more than four times as heavy as water. Its fusing point is lower than that of any other earthy salifiable base. It may be softened by the heat even of a good forge.

V. Zirconia is capable of forming a hydrate. It always exists in this state, when obtained, by precipitation, from solution in acids, and dried slowly, at a moderate heat. When thus combined with water, it has a yellow colour; and a certain degree of transparency, which gives it some resemblance to gum arabic. Hydrate of zirconia.

VI. Zirconia has been ascertained to be an oxide of a peculiar metallic substance, which is called zirconium; but its exact composition has not been made out. Composition of zirconia.

SECTION V.

OF THORINA.*

I. Thorina may be obtained from the minerals, containing protoxide of cerium and yttria; by the following process: Dissolve the mineral in aqua regia; and, after having saturated the filtered solution with liquid ammonia, add to it succinate of ammonia, as long as any precipitate may appear: the succinate of ammonia will throw down the iron. Separate the iron by the filter, and add to the clear solution, sulphate of potash: this addition will precipitate the oxide of cerium. After the oxide of cerium is separated; add, to the remaining solution, liquid ammonia: this addition throws Thorina; how obtained pure.

* From *Thor*, the name of an ancient Scandinavian deity.

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down thorina, in a state of mixture with yttria. For the purpose of separating the yttria; dissolve the precipitate in hydrochloric (muriatic) acid, evaporate the solution to dryness, and treat the dry mass with boiling water: the washing with boiling water will remove nearly all the yttria. Dissolve the part of the mass, not acted upon by the water, in hydrochloric acid, and evaporate the solution, until it become exactly neutral; then treat it with water, and boil for an instant: the small remainder of yttria, present, will remain in solution; while the pure thorina will fall in the form of a powder.

Where found.

II. Thorina has been heretofore detected, only in certain minerals of Sweden. It was discovered in 1815 by Berzelius.

Its properties.

III. Thorina, when first separated by the filter, is a gelatinous semitransparent mass. When dried, it becomes of a white colour. When exposed to the air, it absorbs carbonic acid. Its specific gravity has not been ascertained. It does not fuse when exposed to the highest heats, which can be raised; but contracts in its dimensions, and acquires a certain degree of translucency.

Supposed to be a metallic oxide.

IV. Thorina is presumed, by Berzelius, to be a metallic oxide. To its hypothetical radical, this chemist has given the name of thorinum.

SECTION VI.

OF SILICA.*

Silica; how obtained pure.

I. Silica may be obtained pure by the following process: Fuse together, one part of pounded flint, and three parts of potash, in a crucible: this fusion will render the whole soluble in water. Dissolve the mass in water; and add, to the solution, hydrochloric (muriatic) acid, sufficient to saturate the potash; and then evaporate to dryness. The dry mass consists of silica and chloride of potassium (muriate of potash): the chloride, being soluble, may be washed off by means of a large quantity of water; so that nothing will remain but pure silica.

In what minerals present.

II. Silica is the ingredient most abundantly present, in stony bodies. Flint is composed, almost entirely, of silica. All those rocks, which are called quartz, owe their peculiarities to the presence of this earthy base; which constitutes by much the greater portion of them.

* From *Silex*, the Latin word for flint.

III. All those stones, which are capable of being fused, into a glass, with potash or soda, were formerly called vitrifiable stones. They were considered to derive their peculiar properties from the presence of a certain earth, which was called silicious earth. The existence of such an earth was afterwards called in question; and certain chemists asserted, that it might be converted into other earths. These doubts, however, were afterwards removed by Scheele and Bergman; who established the peculiar nature of silica, beyond all further controversy. Its peculiar nature ascertained.

IV. Silica is a white powder, having a harsh feel; but no taste or smell. It is insoluble in all the acids, except the hydrofluoric (fluoric); with which it forms a compound, having acid properties. It is soluble in solutions of potash or of soda. It produces no change upon vegetable blues. It is found native, crystallized, under the form of rock crystal. It has been crystallized artificially; but the crystals, thus obtained, have not the hardness and beauty of those formed by nature. Properties of silica.

V. Silica is about two and two-third times as heavy as water. It is exceedingly infusible: by the agency of the most intense heats, which can be raised, only minute portions of it can be brought into a state of fusion. It is perfectly insoluble in water, unless when newly precipitated; and even then, it requires 1000 times its weight of this liquid, to dissolve it. Spec. grav. 2·66.

VI. When silica is dissolved in solutions of potash or of soda, and either of these alkaline bases, saturated with an acid; upon evaporating the solution, the silica will assume the form of a gelatinous mass; which becomes a white powder, when dried. Silica combines with these alkaline bases also, by fusion. When the alkaline base exceeds the silica; the compound is soluble in water: on the other hand, if the silica be in excess; the compound is insoluble, and constitutes that useful substance called glass. Silica forms glass by fusion with potash or soda.

1. Glass is a very hard, brittle, transparent substance; fusible at a strong heat, when it becomes exceedingly ductile. It becomes electric by friction. It is insoluble in water, alcohol, and in all the acids, except the hydrofluoric (fluoric). Glass described.

2. Glass is of several kinds. The principal of these are known by the names of flint glass, crown glass, and bottle glass. *Flint glass* is the dearest, most transparent and beautiful. Besides sand and soda, it contains red oxide of lead and peroxide of manganese. The finest and most costly vessels and ornaments of glass are made of this kind. *Crown glass* is composed of soda and fine sand; it is used for window glass. *Bottle glass* is made of soda and com-

mon sand. It is the cheapest and most common of all the kinds of glass. Its green colour is owing to the presence of oxidized iron.

Annealing described.

3. All vessels, of any thickness, made of glass, require to be exposed to a red heat, and then gradually cooled to the temperature of the atmosphere. The purpose, to be answered by this exposure, is to prevent the brittleness, which glass always acquires, when suddenly cooled; and which is supposed to depend upon an unequal contraction of the different strata of its particles. The unequal contraction is entirely prevented, when the glass is gradually cooled. This process, for guarding against the brittleness of glass, is called annealing.

VII. Silica and alumina, when mixed and exposed to a very strong heat, are converted into a kind of opaque glass. These earthy bases constitute the chief part of porcelain, stoneware, bricks and similar substances. Different clays are made up, principally, of a mixture of alumina and silica.

Composition of silica.

VIII. Silica, as the reader has already been informed, is an oxide of a peculiar substance, which is usually classed as a metal, called silicum. It is composed of

Silicum	8
Oxygen	8—one atom.
	16

If the accuracy of the data, upon which the above analysis is founded, could be depended upon; then, supposing silica to be a compound of one atom of each of its constituents, the weight of an atom of silicum would be 8; and that of an atom of silica, 16.

Definition of the class of earthy salifiable bases.

The account of the earthy salifiable bases being thus finished; it is now proper to inform the reader, what distinctive properties, possessed in common by these bodies, form the basis of their arrangement into one class. These bodies were treated of, in a separate class, long before it had been suspected, that they were chemically constituted, in the same manner, as the compounds, usually called metallic oxides; and they have continued to be associated together ever since, from the influence of habit. Perhaps, without much want of precision, the earthy salifiable bases might be defined, to be oxides (not having alkaline properties) of metals, which occur in nature, always combined with oxygen. Such a definition might, indeed, include several of the metallic oxides, (so called); but the want of any precise marks, by which to distinguish the earthy salifiable bases, from some

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of the bodies, usually called metallic oxides, has already been noticed, as an imperfection in the arrangement, which has been adopted.

CLASS III.

SALIFIABLE BASES,

HAVING NEITHER ALKALINE NOR EARTHY PROPERTIES.

Salifiable bases of the third class, are the oxides of certain metals;

Salifiable bases, which have neither alkaline nor earthy properties, include nearly all the oxides of the following metals, viz:

1. Iron.	7. Zinc.	13. Silver.	19. Osmium.
2. Nickel.	8. Lead.	14. Gold.	20. Titanium.
3. Cobalt.	9. Tin.	15. Platinum.	21. Antimony.
4. Manganese.	10. Copper.	16. Palladium.	22. Tellurium.
5. Cerium.	11. Bismuth.	17. Rhodium.	
6. Uranium.	12. Mercury.	18. Iridium.	

If the arrangement, adopted in the present work, had been pursued with attention to rigid accuracy; the description of these oxides ought to have been postponed for this place. But several good reasons conspired to dissuade from the adoption of such an arrangement. The alkaline salifiable bases are too important, to be described under the metals, of which they are the oxides. The earthy salifiable bases had been long considered as simple substances; and arranged accordingly by themselves. This circumstance, taken in conjunction with the importance of some of them, made it expedient to give them a separate consideration. No such reasons, however, exist in favour of the measure of separating the oxides, which are neither alkaline nor earthy in their properties, from the metals, of which they are formed. Accordingly these oxides have been described under the heads of their respective metallic radicals: and they are taken up again, in this place, only for the sake of perspicuity; and to enable the reader to take a complete view of all the salifiable bases.

and are considered, generally, in this place

The salifiable bases of this class are very various in their salifiable power.

Of the metals, which, by their combinations with oxygen, give rise to the formation of salifiable bases of the third class, seven appear to be capable of forming but one oxide; namely, zinc, bismuth, silver, palladium, osmium, antimony* and tellurium: three are capable of forming three oxides; namely, manganese, rhodium and titanium; and all

* In this statement, the word oxide is used in the strict sense. Of course antimonious acid and antimonic acid are not included under its meaning.

the rest, but two oxides. The oxides of zinc, bismuth and silver have the salifiable property in a very perfect degree. As far as the oxide of palladium is known, it does not seem to possess the salifiable power in any remarkable degree. No experiments have proved that oxide of osmium is not salifiable; and yet it is not known to enter into the composition of any salt: in strict propriety it ought not to stand here. Oxide of antimony enjoys the property of neutralizing acids, only in a slight degree; and requires almost always, in its saline combinations, to be associated with a second base. Oxide of tellurium possesses the properties of an acid, more than those of a salifiable base; it enjoys but a very imperfect neutralizing power.

Of the metals, which combine, in three proportions with oxygen, the middle oxides are not known to be salifiable. The remaining oxides, included under this class of salifiable bases, are very various in their salifiable property. The protoxides and peroxides of iron, of nickel, of manganese, of cerium, of uranium, of tin, of mercury, of gold, of platinum, and of titanium, are both salifiable; but not in equal degrees for all these metals. Of tin and mercury, both the oxides possess the salifiable property in nearly equal degree; but the oxides of the former metal, have little affinity for acids. Of all the other metals, just enumerated, except gold and platinum, the protoxides combine with acids, with the greatest facility. With regard to the oxides of gold, there is some doubt whether the protoxide is salifiable; at least, this oxide enters into but one known salt. Of the oxides of platinum, the peroxide seems to be the most readily salifiable. Of some of the metals which have been enumerated, as furnishing the salifiable bases of this class, the protoxides only are salifiable. This is the case with cobalt and lead; for the peroxides of these metals do not enter into the composition of any salt. On the other hand, the peroxides of copper and rhodium, appear alone to be salifiable; while their protoxides do not possess this property. With respect to iridium, too little is known, to enable a decision to be made, with regard to the relative salifiable power of its oxides.

With this general account of the salifiable bases of the third class; the consideration of the whole of the salifiable bases, is completed. Supposing that all the oxides of the metals, which furnish the third class of salifiable bases,

were really known to enter into the composition of some salt; then the total number of salifiable bases of all kinds would be 54: namely,

8 Alkaline salifiable bases;
6 Earthy salifiable bases; and
40 Salifiable bases having neither alkaline, nor earthy properties.

Upon taking a general view of the salifiable bases, it is very readily perceived that these bodies, in chemical nature, bear a very exact analogy to each other; being all, with the exception of ammonia, metallic oxides. They are all solids, the same substance excepted. A comparative view of their properties may be seen in the following tables.

TABLE OF THE ALKALINE SALIFIABLE BASES.

Names.	Synonymes.	Discoverer, and time of discovery.	State as to aggregation.	Colour.	Smell.	Taste.	Solubility.	Effects of exposure to air.	Specific Gravity. Compared with air.	Specific Gravity. Compared with water.	Melting Point.	Composition.	Weight of an atom of each.
1. Ammonia.	Volatile Alkali. Hartshorn.	First obtained pure by Dr. Priestley.	Gaseous.	Colourless.	Exceedingly pungent.	Acrid and hot.	Water takes up 670 times its bulk.		0·590.			Hydrogen three at Azote one ato	
2. Potash.	Pure Kali. Caustic Vegetable Alkali.		Solid.	White.	Like that produced by slaking lime.	Extremely acrid.	Water dissolves twice its weight.	Deliquescent.		1·70.	Fusible.	Potassium one ato Oxygen one ato	
3. Soda.	Caustic Fossil Alkali. Caustic Mineral Alkali.		Solid.	Greyish-white.	Like that produced by slaking lime.	Extremely acrid.	Readily soluble.	Absorbs moisture and carbonic acid, and falls to powder.		1·33.	Fusible.	Sodium one ato Oxygen one ato	
4. Lithia.		Arfwedson; 1818.	Solid.			stic d ine.	Difficultly soluble.	Remains dry.				Lithium one ato Oxygen one ato	
5. Lime.		own from earliest ages.	Solid.	White.		and ing.	Dissolves in 750 times its weight of water.	Attracts moisture and carbonic acid.		2·3.	Very high.	Calcium one ato Oxygen one ato	
6. Baryt		cheele; 1774.	Porous solid.	Greyish white.		and es.	Cold water dissolves 1-20th of its weight; hot water, more than half its weight.	Attracts moisture, swells, and becomes hot.		4·	At a red heat, when a hydrate.	Barium. Oxygen.	
7. Stront		Hope; 1791.	Porous solid.	Greyish white.		id.	Dissolves in 160 times its weight of water.	Attracts moisture and carbonic acid.		Between 3 and 4.	At a red heat, when a hydrate.	Strontium Oxygen.	
8. Magnesia.	Calcined Magnesia.	Distinguished from lime, by Black.	Soft powder.	White.	Inodorous.	Nearly tasteless.	Insoluble.	Attracts moisture and carbonic acid very slowly.		2·3.	Exceedingly high	Magnesia Oxygen.	

TABLE OF THE EARTHY SALIFIABLE BASES.

Names.	Discoverer, and time of discovery.	State as to aggregation.	Colour.	Smell.	Taste.	Solubility.	Effects of exposure to	Specific Gravity.	Melting Point.	Constituents.	Weight of an atom of each.
1. Yttria.	Gadolin; 1794.	Fine powder.	White.	Inodorous.	Tasteless.	Insoluble.		4·842.		Yttrium. Oxygen.	
2. Glucina.	Vauquelin; 1798.	Soft light powder.	White.	Inodorous.	Tasteless.	Insoluble.		[illegible]		Glucinu[illegible] Oxygen.	
3. Alumina.	Margraff; 1754.	Fine powder.	White.	Inodorous.	Tasteless.	Insoluble.		2·	Undergoes the commencement of fusion, in a very intense heat.	Aluminu[illegible] Oxygen.	
4. Zirconia.	Klaproth; 1789.	Fine powder.	White.	Inodorous.	Tasteless.	Insoluble.		4·3	Softened by the heat of a good forge.	Zirconiu[illegible] Oxygen.	
5. Thorina.	Berzelius; 1815.	When just separated, a gelatinous and semi-transparent mass.	White.	Inodorous.					Very infusible.	Presum[illegible] peculia[illegible] and oxy[illegible]	
6. Silica.	Peculiar nature, made out by Bergman and Scheele.	Harsh powder.	White.	Inodorous.	Tasteless.	Insoluble, except when newly precipitated.		2·66.	Exceedingly infusible.	Silicum one ato[illegible] Oxygen one ato[illegible]	

TABLE OF THE SALIFIABLE BASES,

HAVING NEITHER ALKALINE NOR EARTHY PROPERTIES.

NAMES.	COLOUR.	COMPOSITION.	Weight of an atom of each.
1. Protoxide of Iron.	Black.	Iron 28—one atom. Oxygen 8—one atom.	36
2. Peroxide of Iron.	Red.	Iron 56—two atoms. Oxygen 24—three atoms.	80
3. Protoxide of Nickel.	Ash-grey.	Nickel 27—one atom. Oxygen 8—one atom.	35
4. Peroxide of Nickel.	Black.	Nickel 54—two atoms. Oxygen 24—three atoms.	78
5. Protoxide of Cobalt.	Blue.	Cobalt 29—one atom. Oxygen 8—one atom.	37
6. Peroxide of Cobalt.*	Black.	Cobalt 58—two atoms. Oxygen 21—	
7. Protoxide of Manganese.	Olive-green.	Manganese 28—one atom. Oxygen 8—one atom.	36
8. Deutoxide of Manganese.†	Black.	Manganese 56—two atoms. Oxygen 24—three atoms.	80
9. Peroxide of Manganese.	Dark steel-grey.	Manganese 28—one atom. Oxygen 16—two atoms.	44
10. Protoxide of Cerium.	White.		
11. Peroxide of Cerium.	Reddish-brown		
12. Protoxide of Uranium.	Greyish-black.	Uranium 125—one atom. Oxygen 8—one atom.	133
13. Peroxide of Uranium.	Yellow.	Uranium 250—two atoms. Oxygen 24—three atoms.	274
14. Oxide of Zinc.	White.	Zinc 33—one atom. Oxygen 8—one atom.	41
15. Protoxide of Lead.	Yellow.	Lead 104—one atom. Oxygen 8—one atom.	112
16. Peroxide of Lead.*	Flea-brown.	Lead 104—one atom. Oxygen 16—two atoms.	120
17. Protoxide of Tin.	Dark-grey.	Tin 59—one atom. Oxygen 8—one atom.	67
18. Peroxide of Tin.	Yellow.	Tin 59—one atom. Oxygen 16—two atoms.	75
19. Protoxide of Copper.*	Yellow.	Copper 64—one atom. Oxygen 8—one atom.	72
20. Peroxide of Copper.	Black.	Copper 64—one atom. Oxygen 16—two atoms.	80
21. Oxide of Bismuth.	Yellow.	Bismuth 71—one atom. Oxygen 8—one atom.	79
22. Protoxide of Mercury.	Black.	Mercury 200—one atom. Oxygen 8—one atom.	208
23. Peroxide of Mercury.	Bright scarlet.	Mercury 200—one atom. Oxygen 16—two atoms.	216

* The oxides marked thus * do not possess the salifiable property.
† This oxide is not known to enter, as a constituent, into any salt.

TABLE CONCLUDED.

NAMES.	COLOUR.	COMPOSITION.	Weight of an atom of each.
24. Oxide of Silver.	Dark olive-brown.	Silver 110—one atom. Oxygen 8—one atom.	118
25. Protoxide of Gold.*	Green.	Gold 200—one atom. Oxygen 8—one atom.	208
26. Peroxide of Gold.	Reddish-brown.	Gold 200—one atom. Oxygen 24—three atoms.	224
27. Protoxide of Platinum.	Deep-black.		
28. Peroxide of Platinum.	Dark-brown.		
29. Oxide of Palladium.	Chesnut-brown.	Palladium 56—one atom. Oxygen 8—one atom.	64
30 Protoxide of Rhodium.*	Black.		
31 Deutoxide of Rhodium.‡	Brown.		
32. Peroxide of Rhodium.	Red.		
33. Protoxide of Iridium.			
34. Peroxide of Iridium.			
35. Oxide of Osmium.‡	Semi-transparent.		
36. Protoxide of Titanium.	Blue, or purple.		
37. Deutoxide of Titanium.‡	Red.		
38. Peroxide of Titanium.	White.		
39. Oxide of Antimony.	Dirty white.		
40. Oxide of Tellurium.§	White.	Tellurium 32—one atom. Oxygen 8—one atom.	40

* It is doubtful whether these oxides are salifiable.
‡ These oxides are not known to be salifiable.
§ This oxide is salifiable only in an imperfect degree.

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CHAPTER II.

OF ACIDS.

Acids, arranged in five classes.

The acids will be arranged in five classes; each class embracing acids, characterized as follows:

Class I. Acids, whose bases form acid compounds with oxygen or hydrogen indifferently.

Class II. Acids, whose bases form acid compounds with oxygen only.

Class III. Acids, whose bases form acid compounds with hydrogen only.

Class IV. Acids of irregular constitution.

Class V. Acids, in which oxygen and hydrogen are both present.

CLASS I.

ACIDS, WHOSE BASES FORM ACID COMPOUNDS WITH OXYGEN OR HYDROGEN INDIFFERENTLY.

Acids of the first class enumerated.

Acids belonging to this class are the following:

1. Chloric acid.	6. Sulphuric acid.	11. Selenic acid.
2. Oxychloric acid.	7. Sulphurous acid.	12. Hydroselenic acid.
3. Hydrochloric acid.	8. Hyposulphurous acid.	13. Telluric acid.
4. Iodic acid.	9. Hydrosulphuric acid.	14. Hydrotelluric acid.
5. Hydriodic acid.	10. Hydrosulphurous acid.	

These acids will be described in the following sections.

Chlorine forms two acids by combining with oxygen; namely, chloric acid and oxychloric acid. These acids will be noticed in the two following sections.

SECTION I.

OF CHLORIC ACID.

Former chemical name, *Hyperoxymuriatic Acid.*

Chloric acid; how obtained.

I. Chloric acid may be obtained by adding diluted sulphuric acid to a solution of chlorate of barytes, as long as any precipitate should appear: the sulphuric acid combines with the barytes, so as to form an insoluble sulphate of barytes. Remove the insoluble sulphate by the filter; and the remaining liquid will be a solution of chloric acid in water.

II. Berthollet first obtained chloric acid, without being aware of its nature, in a state of combination with potash, by passing a current of chlorine gas, through a solution of carbonate of potash. He suspected that the substance, which became combined with the potash, was different from chlorine (then called oxymuriatic acid); although the manner in which the experiment was conducted, naturally led to a contrary belief. Chenevix afterwards confirmed the suspicion of Berthollet, that the substance which became united with the potash, was not chlorine; and was right in the composition which he assigned to it; if the circumstance be excepted, that he adopted the then prevailing opinion with regard to chlorine, that it was a compound of oxygen and hydrochloric (muriatic) acid. Gay-Lussac, however, first obtained the acid in a separate state, in 1814, by the process just described. Chap. II. Account of its discovery.

III. Chloric acid is a colourless liquid, destitute of smell, unless when concentrated; and possessing a very acid taste. It reddens vegetable blues; but after its action has continued for several days, it destroys them entirely. It is not altered by exposure to light. When exposed to a gentle heat, it may be concentrated, so as to assume an oily consistency; but when subjected to a strong heat, part of it becomes decomposed into oxygen and chlorine; while the remainder distils over without alteration. It does not possess the property of precipitating metals from their solutions. It dissolves zinc rapidly, with the emission of oxygen gas; but it acts feebly upon mercury. Its specific gravity has not been ascertained. It combines with salifiable bases, and forms a genus of salts called chlorates, formerly called, hyperoxymuriates. Its properties.

IV. Chloric acid is composed of Composition.

Chlorine	36—one atom.
Oxygen	40—five atoms.
	76

Giving 76 for the number representing its atom.

SECTION II.

OF OXYCHLORIC ACID.

I. Oxychloric acid may be obtained by the following process: mix 200 grains of strong sulphuric acid with 50 grains of chlorate of potash; so as that the whole may form a yellow coloured mass: a violent chemical action will take place between the constituents of this mixture. As soon as Oxychloric acid; how obtained.

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this action is over; expose the mass to heat, until its yellow colour disappear: by this exposure to heat, the mass becomes a combination of the acid under description, with potash; rendered impure, however, by admixture of bisulphate of potash. Dissolve the mass in water, and let it stand to crystallize: all the bisulphate of potash will separate in crystals; so that, after these are removed, what remains will be a pure solution of oxychlorate of potash. Distil this solution, in a retort, mixed with its own weight of sulphuric acid, at a heat of 280°: the oxychlorate of potash becomes decomposed; sulphate of potash is formed, and oxychloric acid distils over.

Discovery.

II. Oxychloric acid was lately discovered by Count Von Stadion; by whom it was obtained by the process just described.

Its properties not made out.

III. Oxychloric acid has been but very imperfectly examined. None of its properties have, as yet, been ascertained. The only salt, into which it is known to enter as a constituent, is oxychlorate of potash.

Composition.

IV. Oxychloric acid is composed of

Chlorine	36—one atom.
Oxygen	56—seven atoms.
Giving	92 for the number representing

its atom.*

Chlorine forms but one acid with hydrogen; namely, hydrochloric acid. This acid will be described in the following section.

SECTION III.

OF HYDROCHLORIC ACID.

Usual chemical name, *Muriatic Acid.* Old names, *Marine Acid.—Spirit of Sea Salt.*

Hydrochloric acid; how obtained.

I. Hydrochloric acid may be obtained by distilling, in a retort, at the heat of a lamp, a mixture of equal parts of chloride of sodium (common salt) and liquid sulphuric acid. As soon as the mixture is made, a violent effervescence ensues. The gas which is extricated is at first mixed with

* Dr. Thomson calls this acid *perchloric acid.* But I have not followed him in this particular; because his prefix *per* may lead to ambiguity. Should chloric acid prove, hereafter, to be capable of combining with a peroxidized base; the salt which would be formed, would be a perchlorate. Now this is the very name, which would properly belong to a salt, formed by Dr. Thomson's perchloric acid.

atmospheric air, and should be allowed to escape. After the lapse of a few minutes, the pure gaseous product may be collected in glass jars over mercury: it consists of hydrochloric acid.

Process explained.

II. The formation of hydrochloric acid, by the above process, is the result of a very complicated play of chemical affinities. The acid, ready formed, is not present in any of the constituents employed; but is produced by a combination of its ingredients, which takes place during the process. The chloride of sodium becomes decomposed, and, at the same time, a portion of water, with which liquid sulphuric acid is always mixed. The sodium of the chloride, after being first converted into soda, by oxygen furnished by the decomposition of the water, combines with the sulphuric acid, so as to form sulphate of soda; while the chlorine unites with the corresponding hydrogen of the same liquid, so as to form hydrochloric acid.

Account of the discoveries, which led to ascertaining the nature of hydrochloric acid.

III. The nature of hydrochloric acid remained a long time enveloped in uncertainty. It was generally considered to be a compound; yet no one was able to demonstrate its constituents.

The first step, in the investigation, which terminated in the discovery of the true nature of hydrochloric acid, was made by Gay-Lussac and Davy. These chemists ascertained, that the gas, which had been previously called oxymuriatic acid, under the influence of the belief, that it was a compound of muriatic (hydrochloric) acid and oxygen, had never been decomposed; and that neither its reputed constituents, nor any other, could be demonstrated to exist in it. Hence, therefore, it is as yet an undecompounded body. In consequence of this discovery, it became necessary to change its name; and, accordingly, Sir H. Davy substituted, for oxymuriatic acid, the name of chlorine, as has been already mentioned.

The experiment, which was supposed to demonstrate the compound nature of oxymuriatic acid; and that oxygen and muriatic acid were its constituents, was first made by Berthollet. This chemist exposed a saturated solution of oxymuriatic acid to the influence of the light of the sun, for several days; so arranged as to enable him to collect the gaseous products. At the end of this time, the gas which had been extricated, proved to be oxygen; and the oxymuriatic solution was converted into a solution of muriatic acid. The more obvious conclusions to be drawn from this experiment are, that the oxymuriatic acid had been decomposed; that the oxygen, which appeared, was derived from it; and that oxymuriatic acid, deprived of oxygen, became muriatic acid.

The evidence, therefore, that oxymuriatic acid was a compound of oxygen and muriatic acid, appeared to be derived from analysis; and its composition was supposed to be perfectly settled. This continued to be the prevailing opinion, until 1809; when Gay-Lussac and Thenard published some experiments, going to demonstrate that oxygen could not be separated from oxymuriatic acid. In 1810, Sir H. Davy published two papers on the same subject; detailing experiments, which went to prove, that oxymuriatic acid had never been decomposed. This chemist subjected it to a number of trials, with a view, if possible, to detect oxygen in it; but all these trials failed. He found that none of the compounds of oxymuriatic acid with inflammable bodies or metals, could be made to yield a particle of oxygen; and when the oxymuriatic acid gas was subjected to the action of charcoal, intensely ignited in it, or to the strongest powers of electricity, it underwent no change. The experiments and observations of these distinguished chemists were well calculated to throw an air of doubt upon the reality of the decomposition of oxymuriatic acid by Berthollet.

Some time before these new opinions, respecting oxymuriatic acid, were promulgated; it had been observed by Gay-Lussac and Thenard, that, when equal volumes of oxymuriatic acid and hydrogen are exposed to the action of the sun's rays, an explosion takes place; the gases combine, and the product is an equal volume of muriatic acid.* The conclusion, which these chemists first drew from this experiment, was, that muriatic acid gas, as usually obtained, is a compound of dry muriatic acid and water; and that the hydrogen, which disappears, unites with the oxygen of the oxymuriatic acid (adhering to the prevailing opinion respecting its composition), and forms water; while the dry muriatic acid, furnished by the decomposition of the oxymuriatic acid, combining with this water, gives rise to the formation of muriatic acid in its usual state.

The merit of first drawing the proper conclusion from the experiment, above detailed, belongs to Sir H. Davy. This chemist admitted no explanation of it, which required the improper assumption, that oxygen is a constituent in oxymuriatic acid (his chlorine); more especially as the experiments, which seemed to indicate such a constituent in

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* This experiment was performed about the same time by Mr. Dalton, as Dr. Thomson informs us, before the former chemist had any knowledge of what had been done by Gay-Lussac and Thenard.

it, were liable to so obvious a source of fallacy, by the presence of water, or other substances which contain oxygen, as to destroy all confidence in them. He, accordingly, insisted, that the only inference, which could be properly drawn from the experiment, above given, is, that oxymuriatic acid, as an elementary substance, by combining with hydrogen, forms muriatic acid.

Adopting this explanation of the formation of muriatic acid, in the above experiment; the nature of the fallacy in the experiment, by which Berthollet was supposed to indicate the constituents of oxymuriatic acid, is sufficiently manifest. The oxygen, which made its appearance in this experiment, owed its formation to the decomposition of water; the corresponding hydrogen of the same liquid, being employed in the production of the muriatic acid, by combining with the oxymuriatic acid.

If the source of the oxygen, in Berthollet's experiment, be the decomposition of water, as is here contended, and not the oxymuriatic acid; then it ought to be found, that the quantity of hydrogen necessary, by the new theory, to convert any portion of oxymuriatic acid into muriatic acid, is exactly the proper amount, to convert, into water, all the oxygen, which is alleged to be derived from the decomposition of an equal portion of this substance by the old theory. Now this is found to be the fact precisely; for the hydrogen necessary to convert a given portion of oxymuriatic acid into muriatic acid, by the new doctrine, bears the same proportion to the oxygen, which, by the old doctrine, must be separated from it, during the same conversion; as these substances do, to each other, when they unite to form water.

The doctrine of Sir H. Davy, that muriatic acid is a compound of oxymuriatic acid (chlorine) and hydrogen, at first, had many able opponents; who were disposed to coincide in opinion with Gay-Lussac and Thenard, as to its nature. These chemists, however, very soon embraced the new doctrine. Notwithstanding, the new views were still opposed by a number of chemists; but, in the progress of the controversy, new facts were elicited, which confirmed more and more the doctrine of Davy; and, since the recent discovery of iodine; which, among other striking analogies to oxymuriatic acid, possesses the property of forming an acid with hydrogen; the new explanations are almost universally admitted.

It may conduce to give a clearer idea of the new views and explanations, which have been introduced into chemistry, by the discoveries, connected with muriatic acid, to

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ed), before it is employed to form the oxyhydrochloric acid; the result will be the production of this acid, in the highest state of oxidizement, which Thenard was capable of effecting. By pursuing these processes, this chemist succeeded in obtaining an hydrochloric acid, containing 16 times its volume of oxygen.

The combination of hydrochloric (muriatic) acid and oxygen, which has thus been discovered by Thenard, ought to have proved identical with chlorine (oxymuriatic acid); if the old theory, respecting the composition of the latter substance, had been correct. But this is very far from being the case. The advocates of the former doctrine may now satisfy themselves, that a real oxymuriatic acid and chlorine are distinct substances.*

Water, saturated with hydrochloric acid, forms liquid hydrochloric acid.

VIII. Water saturated with hydrochloric acid gas, is, in common language, called muriatic acid. This solution of the acid gas, in water, is the only form, in which the acid is used for the ordinary purposes of chemistry, or in medicine. When hydrochloric acid is spoken of; it is to be always understood, unless otherwise specified, that the solution of the gas in water is meant. The liquid form of the acid will now be considered.

LIQUID HYDROCHLORIC ACID.

Usual chemical name, *Muriatic Acid.*

Liquid hydrochloric acid; how obtained for medical use.

1. The Edinburgh college directs the following process for obtaining the liquid acid: Expose two pounds of chloride of sodium, (common salt) to a red heat for some time. After the chloride has cooled; put it in a retort, and pour upon it sixteen ounces of sulphuric acid, previously diluted with one pound of water. Distil the mixture, in a sand bath, at a moderate heat, as long as any acid comes over.

Process explained.

2. The explanation of this process is the same with that given of the formation of the acid in the gaseous state; with this difference only, that the water, directed by the Edinburgh college, distils over in combination with the gaseous acid.

Its properties.

3. Liquid hydrochloric acid, when perfectly pure, is colourless; but, as usually obtained, it has a pale yellow colour, owing to the presence of a small portion of iron. It possesses the peculiar smell of the gaseous acid. When ex-

* See Thenard's paper, as translated in the Annals of Philosophy, (Jan. 1819.)

posed to the air, it gradually emits the acid gas, which combines with the moisture of the atmosphere, and appears in white fumes. It is about one and one-fifth times as heavy as water.

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Spec. grav. 1·203.

4. When the liquid acid is formed by saturating cold water with the acid gas, the water becomes hot; and, as the heating advances, the absorbing power of the water diminishes, until the heat arrives at the boiling point, when it is entirely lost. Hence it is, that, if the liquid acid be exposed to heat, the acid gas may be procured. It was in this way that Dr. Priestley first obtained the acid in the gaseous form.

Composition.

5. Liquid hydrochloric acid, when a perfectly saturated solution, contains 515 times its volume of the acid gas; or more than half its weight.

Medical properties.

6. Liquid hydrochloric acid acts as a stimulant, when taken into the stomach. In low fevers of all kinds, when diluted sufficiently to be agreeably sour, it is a very proper drink. In relaxed states of the stomach, it has been found useful in restoring the tone of that organ; but, for this purpose, liquid sulphuric acid is generally preferred. Almost any quantity of the solution may be taken, when sufficiently diluted.

IX. Hydrochloric acid is not capable of combining with any of the undecompounded combustibles. When the attempt is made to combine the acid with some of them, it becomes decomposed; its chlorine forms a chloride with the combustible, and its hydrogen is evolved.

X. Hydrochloric acid combines with some of the salifiable bases, and gives rise to a genus of salts, which will be called hydrochlorates. These salts are usually called muriates. Most of them, when exposed to a red heat, undergo a double decomposition; so as to be converted into a chloride and water.

Composition of hydrochloric acid.

XI. Hydrochloric acid is composed of

Chlorine	36—one atom.
Hydrogen	1—one atom.
	37

Giving 37 for the number representing the weight of its atom.

Employed to destroy miasmata.

XII. This acid has been employed to destroy contagion, and putrid miasmata. Morveau used it, with success, for neutralizing the putrid exhalations, which pervaded the cathedral of Dijon. But, for these purposes, it is inferior to chlorine.

Iodine forms iodic acid with oxygen.

Iodine forms but one acid compound with oxygen; namely, iodic acid. This acid will be described in the following section.

SECTION IV.

OF IODIC ACID.

Iodic acid; how obtained.

I. IODIC ACID may be obtained by the following process: Put into a bent tube, closed at one end, 100 grains of chlorate of potash; and pour upon them, 400 grains of hydrochloric acid, of the specific gravity of 1·105. Make the bent tube communicate with a long necked receiver, containing 40 grains of iodine; and apply a gentle heat to the mixture, which it contains. A quantity of protoxide of chlorine is immediately formed. As soon as this gaseous oxide enters the receiver; each of its constituents combines with a portion of the iodine, and gives rise to the formation of two acids; the acid under description, and another acid, which is called chloriodic acid. By exposing the mixed acids to heat, the chloriodic acid, being volatile, flies off; while the iodic acid remains behind. This acid was first obtained, in a separate state, by Sir H. Davy.

Its properties.

II. Iodic acid is a white semi-transparent solid, destitute of smell; but possessing a strong, astringent, sour taste. When exposed to a moist atmosphere, it gradually deliquesces. When heated to a temperature, a little below that, at which olive oil boils; it is decomposed into iodine and oxygen. It sinks rapidly in sulphuric acid; hence its specific gravity must be considerable. It is readily soluble in water. Its solution first reddens, and afterwards destroys, vegetable blues. When it is exposed to heat, the water gradually evaporates, and the acid is reduced to the consistency of syrup. Afterwards, if the heat be increased, the acid may be driven over unaltered; but, when the temperature arrives at a certain point, the acid becomes decomposed.

III. Iodic acid has the property of combining with a number of acids, as was first ascertained by Sir H. Davy. With those already described, however, it does not appear capable of combining. When iodic acid and hydrochloric acid are brought into contact; they mutually decompose each other, and the products are water and chloriodic acid. Iodic acid combines with several of the salifiable bases, and forms salts, called iodates.

Composition of iodic acid.

IV. Iodic acid is composed of

Iodine	125—one atom.	
Oxygen	40—five atoms.	

Giving 165 for the number representing the weight of its atom.

Iodine forms hydriodic acid, with hydrogen.

Iodine forms but one acid compound with hydrogen; namely, hydriodic acid. This acid will be described in the following section.

SECTION V.

OF HYDRIODIC ACID.

Hydriodic acid; how obtained.

I. Hydriodic acid may be obtained, by exposing, in a retort, to heat, a mixture, moistened with water, of four parts of iodine, and one part of phosphorus. A gas is immediately formed, which must be collected over mercury. This gas is hydriodic acid.

II. Hydriodic acid was discovered by Clements; but its properties were first investigated by Davy and Gay-Lussac.

Its properties.

III. Hydriodic acid is an invisible and elastic fluid, like common air. Its smell is similar to that of hydrochloric acid. Its taste is very sour. When brought in contact with chlorine, hydrochloric acid is formed, and iodine deposited.

Spec. grav. 4·443.

IV. It is about four and a half times as heavy as common air.

Combines with water.

V. Liquid hydriodic acid is readily formed by saturating water with the gaseous acid. It may be formed also, by passing a current of hydrosulphuric acid gas (sulphuretted hydrogen) through water, in which a portion of iodine is previously placed. The hydrogen of the acid combines with the iodine; and its sulphur is deposited. Liquid hydriodic acid may be concentrated by exposure to a heat, under 262°. In this way, its specific gravity may be increased to 1·7. At the temperature of 262°, it boils, and may be distilled over. It has the property of dissolving iodine; whereby it assumes a dark colour.

Composition of hydriodic acid.

VI. Hydriodic acid is composed of

Iodine	125—one atom.
Hydrogen	1—one atom.

Giving 126 for the number representing its compound atom.

Sulphur forms three acids with oxygen.

Sulphur forms three acid compounds with oxygen; namely, sulphuric acid, sulphurous acid, and hyposulphurous acid. These acids will be described in the three following sections.

SECTION VI.

OF SULPHURIC ACID.

Sulphuric acid; how obtained pure.

I. Sulphuric acid may be obtained by the following process: Distil sulphate of iron (green vitriol), which has previously been exposed to heat, to drive off its water of crystallization: a black coloured fuming substance will come over, very nearly twice as heavy as water; it constitutes the fuming sulphuric acid, as prepared, for many years, in Nordhausen in Germany. Distil this fuming liquid, in a retort, with a moderate heat, into a receiver surrounded with ice: a vapour is driven over; which condenses in the receiver. If the distillation be stopped in time, the condensed vapour will consist of pure sulphuric acid.

Process explained.

II. The fuming sulphuric acid of Nordhausen is considered to be a very concentrated sulphuric acid, containing but little water. The manner of its preparation indicates this to be its nature; being distilled from dried sulphate of iron. Now when this fuming acid is distilled cautiously, nothing but the pure acid is driven over; what water it may have contained, being left behind.

Its properties.

III. Sulphuric acid is a solid under the temperature of 66°; but above that temperature, it assumes the form of colourless vapour, which takes on the appearance of white clouds, when it comes in contact with moist air. In the solid form, it is composed of filaments, having a silky appearance; which gives the acid some resemblance to the mineral substance, called asbestos. It is tough, and cannot be easily cut. When exposed to the air, it fumes, and gradually flies off in the form of vapour. When held between the fingers, it exerts no action upon the skin; but after some time, it produces pain. The specific gravity of this acid, either in the solid form, or in the state of vapour, has not been ascertained.

Dissolves in water, and forms liquid sulphuric acid.

IV. Sulphuric acid has a strong affinity for water. When thrown into this liquid; the combination takes place with such rapidity, as to produce a noise, similar to that caused by a red hot iron, under equal circumstances. Sulphuric acid, dissolved in a certain quantity of water, forms liquid sulphuric acid, or the sulphuric acid of commerce.

LIQUID SULPHURIC ACID.

Former name, *Vitriolic acid.* Common name, *Oil of Vitriol.*

1. When the pure solid sulphuric acid is dissolved in about one-fifth of its weight of water, it forms liquid sulphuric acid, of the usual strength, in which it occurs in commerce. Liquid sulphuric acid;

2. Liquid sulphuric acid is obtained by the manufacturer, by burning a mixture of one part of nitrate of potash (nitre) and seven parts of sulphur, in chambers lined with lead; whose floors are covered with a certain depth of water. The water becomes impregnated with the acid; and when the impregnation has reached to a certain degree, the acid water is concentrated, by evaporation, first in leaden retorts, as long as the acid is too weak to act upon them; and afterwards in glass retorts, until it become of a certain strength. This strength, for the purposes of commerce, is indicated by a specific gravity of about 1·85. The acid may be concentrated beyond this strength; but it has not been found possible, by any distillation, to drive off all the water, which it contains. how obtained by the manufacturer.

3. The rationale of the formation of liquid sulphuric acid by the above process, is thus given by Clement and Desormes, and Davy. The combustion of a mixture of sulphur and nitrate of potash (nitre) gives rise to the formation of sulphurous acid and deutoxide of azote (nitrous gas). The latter of these substances is immediately converted into nitrous acid, by coming in contact with the air. The acid thus formed and the sulphurous acid then combine, lose their gaseous form and precipitate into the water. As soon as the combined acids come in contact with the water, the sulphurous acid becomes converted into sulphuric acid, by combining with a dose of oxygen, at the expense of the nitrous acid; which latter is thereby brought back to the state of deutoxide of azote; and thus changed, assumes, again, the gaseous form. No sooner does it come in contact with the air, than it is again converted into nitrous acid, precipitates in combination with sulphurous acid, converts the latter acid into sulphuric acid, and again assumes the gaseous form, as deutoxide of azote. The same round of compositions and decompositions is repeated as long as any sulphurous acid may remain. Manufacturer's process explained.

4. Liquid sulphuric acid was discovered, in the middle ages, either by the Arabian chemists, or the alchemists. It is spoken of by Basil Valentine, who wrote early in the fifteenth century. It was, for a long time, obtained by distilling sulphate of iron (green vitriol); a process which is Account of the discovery of the liquid acid.

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still followed in Germany. It was afterwards prepared by burning a mixture of sulphur and nitrate of potash (nitre) under a glass bell. From this mode of preparation, it was formerly frequently called *oleum sulphuris per campanam.* The method, which has been described at length in the beginning of the present account, and which is pursued by almost all the manufacturers of sulphuric acid, was invented by Dr. Roebuck; who established the first manufactory of the kind, at Prestonpans in Scotland.

Properties of the liquid acid.

5. Liquid sulphuric acid is colourless like water. It is nearly destitute of smell, but possesses an intensely sour taste. It has somewhat of an oily consistency; from which circumstance it has got the common name of oil of vitriol. It reddens vegetable blues. It acts upon animal and vegetable substances with considerable energy, and speedily converts them into charcoal. Its specific gravity and boiling point vary with the quantity of water which it may contain. When composed of

Sulphuric acid	40—one atom,
Water	9—one atom; its specific

gravity is 1·85,—and its boiling point, 620°. When composed of

Sulphuric acid	40—one atom,
Water	18—two atoms; its speci-

fic gravity is 1·78,—and its boiling point, 435°. When composed of

Sulphuric acid	40—one atom,
Water	27—three atoms; its spe-

cific gravity is 1·65, and its boiling point, 350°.—Water, however, does not combine with sulphuric acid, only by atoms. So far from this being the case, it appears capable of uniting with the acid, in every proportion. It is not easy to reconcile this fact with the atomic theory.

6. Liquid sulphuric acid, when exposed to the air, attracts moisture, and becomes heavier. The quantity of water, which it is capable of absorbing in this way, is always less, as the quantity of this liquid, which it already contains, is greater.

7. The congealing point of liquid sulphuric acid varies with its density. But it is found that this variation takes place in such a way, as that the freezing point of the acid lowers, according as its density varies, either above or below a certain density. The freezing point of liquid sulphuric acid, of the specific gravity of 1·78 is at 45°. Now it is found, that if the acid be much more, or much less concentrated; its freezing point lowers considerably. When

concentrated as far as possible, its freezing point is as low as — 36°. Chap. II.

8. Liquid sulphuric acid is decomposed by many of the undecompounded combustibles. Action of the liquid acid upon combustibles.

[1.] When liquid sulphuric acid and hydrogen are made to pass together, through a red hot porcelain tube; the acid is completely decomposed, water is formed, and sulphur deposited. At a boiling temperature, it is converted, by charcoal, into sulphurous acid; but by the action of the same combustible, at a red heat, it is totally decomposed. When heated in contact with phosphorus; sulphurous acid is disengaged, and the phosphorus becomes converted into phosphoric acid. When boiled along with sulphur, it becomes converted into sulphurous acid.

[2.] Liquid sulphuric acid, when very much diluted, acts violently upon zinc and iron. Part of the water present is decomposed; these metals are oxidized, and hydrogen is evolved. When the acid is concentrated, it acts upon these metals, but much less violently; part of the acid, in this case, being decomposed, and flying off in the form of sulphurous acid. Upon tin and copper, the action of the liquid acid is but feeble, unless it be assisted by heat; in which case, it oxidizes and dissolves them. On silver, mercury, antimony, bismuth, arsenic and tellurium, a pretty high temperature is required for the acid to produce any effect; and the action, which takes place, consists in the oxidizement of these metals, at the expense of part of the acid, which flies off in the form of sulphurous acid; while the remainder combines with the oxides formed. At the boiling temperature, it oxidizes lead, and dissolves cobalt, nickel and molybdenum. The liquid acid exerts no perceptible action upon gold or platinum.

9. When liquid sulphuric acid is dropped into a concentrated solution of iodic acid; the two acids fall, in combination, in the form of a solid precipitate. This precipitate, after fusion, assumes the form of crystals, which have a pale yellow colour. When strongly heated, it is partly sublimed, and partly decomposed into oxygen, iodine and sulphuric acid.

10. Gay-Lussac, has lately succeeded in oxidizing liquid sulphuric acid. His method consisted in adding his recently discovered oxyhydrochloric acid to sulphate of silver. The products are chloride of silver, water and oxysulphuric acid. The formation of oxysulphuric acid has already been noticed, when detailing the different methods for obtaining oxyhydrochloric acid, page 191. The liquid acid, capable of being oxidized.

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The liquid acid, used in medicine.

11. Liquid sulphuric acid, when sufficiently diluted, furnishes a very powerful article to the materia medica. Its general action is that of a stimulant and tonic. In weak and relaxed states of the stomach, it is used to excite appetite and to promote digestion. It is a useful acidulous drink, in all fevers, below the par of action. When taken in large quantities, it passes off by the kidneys and the skin.

V. Sulphuric acid combines with the salifiable bases, and forms salts, which are called sulphates. These salts will be described under the heads of their respective bases.

Composition of sulphuric acid.

VI. Sulphuric acid is composed of

Sulphur	16	—one atom.
Oxygen	24	—three atoms.
Giving	40	for the number represent-

ing its compound atom.

SECTION VII.

OF SULPHUROUS ACID.

Phlogisticated Sulphuric Acid, of Stahl.

Sulphurous acid; how obtained.

I. Sulphurous acid may be obtained by the following process: Expose a mixture of two parts of mercury, and one part of sulphuric acid, in a retort, to the heat of a lamp: an effervescence takes place, and a gas is extricated, which must be collected, in glass vessels, over mercury. This gas is sulphurous acid. In this process, the mercury robs the sulphuric acid of just so much oxygen, as to convert it into sulphurous acid; which, being a gas, causes the effervescence, just spoken of. The acid gas is collected over mercury, in consequence of its absorbability by water.

Its history.

II. Sulphurous acid was first examined by Stahl. About the year 1774, Scheele and Priestley obtained it in the gaseous form, and described many of its properties. Since that time, it has been thoroughly examined, by Berthollet in 1782 and 1789; by Fourcroy and Vauquelin in 1797, and by Thomson in 1803.

Its properties.

III. Sulphurous acid is a gaseous fluid, transparent and colourless, like common air. Its taste is exceedingly acid and sulphurous. Its smell is strong and suffocating, resembling exactly, that produced by the burning of sulphur. It changes vegetable blues, first to red, but afterwards destroys them. It destroys the colours of many animal and vegetable substances; which property makes it useful in the bleaching

of wool, and for removing stains from linen, produced by fruit. Chap. II.

IV. Sulphurous acid gas is about two and one-fifth times as heavy as atmospheric air. When exposed to a cold of — 18°, in a state of compression, it is condensed into a liquid. It does not support combustion. Neither is it fit for respiration. Animals forced to breathe it are very soon destroyed. Spec. grav. 2·22.

V. Water, when perfectly saturated, contains 33 times its volume of this acid gas: or by weight, 100 parts of water take up 91·5 parts of the gas. When thus combined with water, it constitutes liquid sulphurous acid. It is very little heavier than water. It may be frozen, without parting with any of the gas which it contains. Absorbable by water.

VI. Sulphurous acid gas and oxygen gas, when dry, do not act upon each other; but if moist, they combine gradually, and the product is sulphuric acid. These gases combine also by heat and electricity.

VII. At a red heat, sulphurous acid gas is decomposed by hydrogen and charcoal; water and carbonic acid are formed, and sulphur deposited. It is not decomposed by sulphur or phosphorus, under similar circumstances. Action of combustibles.

VIII. Of the metals, sodium and potassium decompose this acid gas readily. Iron dissolves in it, without the evolution of any gas. The peroxides of lead and of manganese absorb it, and are converted into sulphates of these metals. This occurs in consequence of the transfer of part of the oxygen of these oxides, to the sulphurous acid; whereby the latter is converted into sulphuric acid. The action of the other metals on this acid gas, is but imperfectly known.

IX. Sulphurous acid gas is composed of Composition of sulphurous acid.

Sulphur	16—one atom.
Oxygen	16—two atoms.
Giving	32 for the number representing

its compound atom.

SECTION VIII.

OF HYPOSULPHUROUS ACID.

I. Oxygen combines with sulphur in a smaller proportion than that which exists in sulphurous acid. This compound of oxygen and sulphur exists in certain salts, which have been called hyposulphites. Although it has never been ob- Hyposulphurous acid has never been obtained in a separate state.

tained in a separate state, it is supposed to possess acid properties, and the name hyposulphuric acid has been assigned to it.

II. It is considered to be composed of

Sulphur	16—one atom.	
Oxygen	8—one atom.	
Giving	24 for the number representing its atom.	

Sulphur forms two acids with hydrogen.

Sulphur forms two acid compounds with hydrogen. These compounds are usually known by the names of sulphuretted hydrogen, and supersulphuretted hydrogen. They will be described in the two following sections, under the names of hydrosulphuric acid, and hydrosulphurous acid.*

SECTION IX.

OF HYDROSULPHURIC ACID.

Usual chemical name, *Sulphuretted Hydrogen. Hydrothionic*† *Acid*, of the German Chemists.

Hydrosulphuric acid; how obtained.

I. HYDROSULPHURIC ACID may be obtained by pouring diluted sulphuric acid upon the mass formed by fusing together, in a crucible, three parts of iron filings and two parts of sulphur. The gas, which becomes immediately extricated, consists of hydrosulphuric acid. It must be collected over mercury; being absorbable by water. When obtained by this process, however, it is generally contaminated with hydrogen. It may be obtained, perfectly pure, by digesting

* These names were proposed by me, for the compounds of sulphur and hydrogen, in an essay, which I read in 1812, before the Columbian Chemical Society, and which was published, the succeeding year, in their Memoirs.§ The same name has been proposed for one of them, namely sulphuretted hydrogen, by Gay-Lussac.

I have adopted the name hydrosulphuric acid, for sulphuretted hydrogen, not only because the compound has acid properties; but especially because recent discoveries have made chemists acquainted with acids, precisely analogous in composition, in which a similar plan of nomenclature has been adopted, or proposed by high authority. The acids alluded to are the hydrochloric, the hydriodic, and the hydrocyanic acids. With regard to the supersulphuretted hydrogen, this compound is probably a binary combination of sulphur and hydrogen. It combines with some of the salifiable bases, and forms compounds, in many respects, analogous to salts. These circumstances, together with that of its containing less hydrogen than sulphuretted hydrogen, have induced me to venture upon giving it a name, with the characteristic termination of a sub-acid, and to place it among the acid bodies.

† From hydrogen and θειον sulphur.

§ Memoirs of the Columbian Chemical Society, p. 130.

sulphuret of antimony, in powder, in hydrochloric (muriatic) acid. CHAP. II.

II. The properties and composition of this gas were first investigated by Scheele in 1777. The gas was further examined, in 1786, by Kirwan; who first shewed that it possessed acid properties. This conclusion of Kirwan was fully confirmed by Berthollet in 1794. It was still further investigated by Berzelius in 1807; and, more lately, by Gay-Lussac and Thenard, and Davy. Its history.

III. Hydrosulphuric acid is a colourless and elastic fluid, like common air. Its smell is strong and fetid, not unlike that of rotten eggs. When in solution in water, it converts vegetable blues to red. It is about one and one-fifth times as heavy as common air. It is capable of combustion. When set on fire, it burns with a bluish-red flame; and a quantity of sulphur is deposited. When electric sparks are passed through it; it is converted into an equal bulk of hydrogen gas; the sulphur being deposited. When its combustion is complete, it is converted into water and sulphurous acid. Its properties. Spec. grav. 1·19.

IV. This acid gas is not fit for respiration. Animals forced to breathe it are destroyed.

V. Hydrosulphuric acid gas is rapidly absorbed by water; in which state of solution, it forms liquid hydrosulphuric acid. When the liquid acid is a perfectly saturated solution, it contains about two and a half times its bulk of the gas. The liquid acid possesses the property of precipitating nearly all the metals from their solutions. The metal falls generally as a sulphuret; the hydrogen of the acid and the oxygen of the metallic oxide, going to form water. The acid, therefore, becomes a very useful test for the presence of metals in solution; more especially as the colour of the precipitate produced most generally indicates the particular metal present. The colour of the metallic precipitates, which it produces, may be seen in the following statement. Forms with water, liquid hydrosulphuric acid; which precipitates nearly all the metals.

Gold and Platinum are reduced.		Lead is precipitated	Black.
Silver is precipitated	Black.	Zinc	White.
Mercury	Black.	Bismuth	Black.
Palladium	Dark-brown.	Antimony	Orange.
Copper	Black.	Arsenic.	Yellow.
Tin	Brown.	Molybdenum.	Chocolate.

Iron, nickel, cobalt, manganese, cerium, uranium and titanium are not precipitated from solution, in the mineral acids, by liquid hydrosulphuric acid; and but imperfectly from solution in vegetable acids.

VI. Hydrosulphuric acid combines with most of the salifiable bases, and forms a set of compounds, which are Forms with bases, hy-

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very analogous to salts. These combinations will be described under the heads of their respective bases.

drosulphates. Its composition.

VII. Hydrosulphuric acid is composed of

Sulphur	16—one atom.	
Hydrogen	1—one atom.	

Giving 17 for the number representing the weight of its atom.

SECTION X.

OF HYDROSULPHUROUS ACID.

Usual chemical names, *Hydroguretted Sulphur.—Supersulphuretted Hydrogen.*

Hydrosulphurous acid; how obtained.

I. Hydrosulphurous acid may be obtained by adding, gradually, hydrochloric (muriatic) acid, to the brown-coloured liquid, obtained by boiling together, liquid potash and sulphur. Hydrosulphuric acid is evolved, and, at the same time, a substance precipitates. This substance is hydrosulphurous acid.

II. Hydrosulphurous acid was first noticed by Scheele; but it was Berthollet who first ascertained its chemical nature.

Its properties.

III. Hydrosulphurous acid is a liquid of a yellowish-brown colour, having considerable resemblance to oil. When exposed to heat, it drops a portion of its sulphur, and exhales in the form of hydrosulphuric acid gas. A similar decomposition of it takes place upon exposure to air. It forms, with some of the salifiable bases, compounds, which are usually called *hydroguretted sulphurets.* They will be called, in the present work, hydrosulphites, and be described under the heads of their different bases.

Selenium forms selenic acid with oxygen.

Selenium forms one acid compound with oxygen; namely, selenic acid. This acid will be noticed in the following section.

SECTION XI.

OF SELENIC ACID.

Selenic acid; how obtained.

I. Berzelius has ascertained, that if selenium be heated in a large flask, full of oxygen gas or atmospheric air, it evaporates, without undergoing combustion, and is converted into a gaseous oxide. This fact ought to have been

mentioned under the head of selenium. On the other hand, if selenium be exposed to heat in a hollow globe of glass, about an inch in diameter, in which it has not room to evaporate, and a current of oxygen be made to pass through it; this peculiar substance, at the moment of ebullition, enters into combustion, with a flame, white at its base, but green, or bluish-green, at the edges, and sublimes without residue. The sublimed product is selenic acid. Selenium is converted into selenic acid also, by the action of nitric or sulphuric acid, or aqua regia.

Its properties.

II. Selenic acid, immediately after it is formed, has a lustre peculiar to itself, which it soon loses by the absorption of humidity from the air. It has an acid taste, leaving a weak burning sensation upon the tongue. In the form of gas, it has a penetrating odour. It dissolves readily in cold water, and in all proportions in boiling water. It combines with salifiable bases, so as to form peculiar salts.

Composition.

III. Selenic acid is composed, in whole numbers, of

Selenium	40—one atom.
Oxygen	16—two atoms.

Giving 56 for the number representing the weight of its atom.*

Selenium forms hydroselenic acid with hydrogen.

Selenium forms one acid compound with hydrogen, which is called by Berzelius, selenuretted hydrogen. It will be noticed, in the following section, under the name of hydroselenic acid.

SECTION XII.

OF HYDROSELENIC ACID.

Hydroselenic acid; how obtained.

I. HYDROSELENIC ACID may be procured, by pouring diluted hydrochloric (muriatic) acid upon selenuret of potassium, contained in a small retort. The selenuret swells and becomes red, and a gas is extricated. This gas is hydroselenic acid. It was discovered by Berzelius.

Its properties.

II. Hydroselenic acid is an invisible and elastic fluid, like common air. It acts, with great violence, upon the organs of respiration and of smell. A bubble of the gas, not larger than a pea, is capable of destroying the sense of smell, so far, as not to be sensible to the impression of ammonia for several hours. The irritation, which it produced,

* Berzelius, Annales de Chimie et de Physique IX. 231. et seq. (Nov. 1818.)

caused a violent defluxion from the nose, and the eyes to become instantly red. It dissolves in water, totally deprived of air, without decomposition; but the presence of the smallest quantity of air, causes the solution to assume a red colour. This appearance of a red colour is owing to the reduction of the selenium; the hydrogen of the acid, combining with the oxygen of the common air present, forming water. The solution is colourless, and possesses an hepatic taste. It stains the skin of a brown colour, which cannot be removed by washing. It becomes decomposed by exposure to air, first in the upper parts, but afterwards the whole, and changes throughout to a red colour; the selenium being reduced. It precipitates all metallic solutions, not excepting those of zinc and iron, when in a neutral state. All these precipitates are of a black or brown colour, except those of zinc, manganese, and cerium, which are of a flesh colour. The acid gas combines with some salifiable bases, and forms compounds analogous to salts.

Composition.

III. Hydroselenic acid is composed, in whole numbers, of

Selenium	37
Hydrogen	1
	38*

—Supposing it a compound of one atom of each of its constituents; then the weight of an atom of selenium would be represented by the number 37. Thus it is perceived, that the same equivalent number cannot be deduced from the consideration of the selenic and hydroselenic acids.

Tellurium forms telluric acid with oxygen.

Tellurium forms one acid compound with oxygen; namely, telluric acid. This acid will be noticed in the following section.

SECTION XIII.

OF TELLURIC ACID.

Telluric acid, already described as a salifiable base.

I. Tellurium forms, with oxygen, but one compound, which, in different salts, sometimes performs the part of an acid, and sometimes of a salifiable base. As the account of the salifiable bases precedes that of the acids, in this work, it became necessary to describe this compound first as a salifiable base; and this is done under the head of tellurium, page 49. It is mentioned here incidentally, in order that

* Berzelius, Annales de Chimie et de Physique IX. p. 231. et seq. (Nov. 1818.)

the enumeration of the acids, embraced by the present class, may be complete. Chap. II.

Tellurium forms one acid compound with hydrogen. This combination is generally called telluretted hydrogen. It will be noticed, under the name of hydrotelluric acid, in the following section.

Tellurium forms hydrotelluric acid, with hydrogen.

SECTION XIV.

OF HYDROTELLURIC ACID.

I. Hydrotelluric Acid may be formed by pouring diluted sulphuric acid upon a mixture of oxide of tellurium, potash and charcoal, the latter having been previously exposed to a red heat. A gas is immediately evolved, which must be collected over mercury. This gas is hydrotelluric acid. It was discovered, in 1809, by Sir H. Davy.

Hydrotelluric acid, how obtained.

II. Hydrotelluric acid is a colourless and elastic fluid like common air. Its smell is strong and peculiar, and somewhat resembles that of hydrosulphuric acid (sulphuretted hydrogen). It burns with a bluish flame, and is converted into oxide of tellurium. Its solution in water has a claret colour. Like hydrosulphuric acid, it precipitates most metallic solutions. It is capable of neutralizing salifiable bases, with which it forms compounds analogous to salts.

Its properties.

CLASS II.

ACIDS, WHOSE BASES FORM ACID COMPOUNDS, WITH OXYGEN ONLY.

Acids belonging to this class are:

Second class of acids enumerated.

1. Nitric Acid.	7. Phosphorous Acid.	12. Molybdic Acid.
2. Nitrous Acid.	8. Hypophosphorous Acid.	13. Molybdous Acid.
3. Hyponitrous Acid.	9. Arsenic Acid.	14. Tungstic Acid.
4. Carbonic Acid.	10. Arsenious Acid.	15. Columbic Acid.
5. Boracic Acid.	11. Chromic Acid.	16. Antimonic Acid.
6. Phosphoric Acid.		17. Antimonious Acid.

These acids will be described, in the order in which they have been enumerated, in the following sections.

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Azote forms three acids with oxygen.

Azote forms three acids with oxygen; namely, nitric acid, nitrous acid, and hyponitrous acid. These acids will be described in the three following sections.

SECTION I.

OF NITRIC ACID.

Common names, *Spirit of Nitre.—Aqua Fortis.*

Nitric acid; how obtained.

I. Nitric acid may be obtained by the following process: Mix two parts of nitrate of potash (nitre) with one part of sulphuric acid, in a glass retort. Adapt, to the mouth of the retort, a receiver, from which a glass tube passes into one of the exterior openings of a bottle with three mouths. Pour a little water into the bottle, and fix a tube of safety* to its central mouth. To its third mouth, adjust a second tube, and let it communicate with the pneumatic trough. The apparatus being thus arranged, apply heat to the retort, and gradually increase it, until it reach the temperature of 500°. A vapour is evolved, which condenses in the receiver. This condensed vapour consists of nitric acid, holding in solution a portion of deutoxide of azote (nitrous gas). Expose it, for some time, to the influence of heat: the deutoxide of azote will be driven off; and the nitric acid, left behind. The nitric acid is formed in this process, in consequence of the decomposition of the nitrate of potash. The sulphuric acid combines with its potash, while the nitric acid is extricated in the form of vapour.

II. The Edinburgh college directs the following process for preparing nitric acid: Expose nitrous acid, in a retort, furnished with a receiver, to a very gentle heat, until its reddest portion shall have passed over. What remains in the retort will be nitric acid. The liquid, which is called by the Edinburgh college, nitrous acid, is in fact nitric acid, holding, in solution, a quantity of deutoxide of azote (nitrous gas). The same kind of nitric acid is obtained in the process detailed in the preceding paragraph. When it is exposed to heat, the deutoxide of azote is driven off.

* A tube of safety is a tube, which is fixed in vessels, in which distillations are made, with one end open, communicating with the external air, and the other immersed below the surface of the liquid contained in them. It has the effect of preventing the bursting of vessels; for if a vacuum take place, the air rushes down the tube of safety, and restores the equilibrium of pressure. On the other hand, if any gaseous fluid be suddenly extricated, the contained liquid is forced up the tube.

III. Nitric acid appears to have been first obtained by Raymond Lully, a chemist, who lived in the 13th century. CHAP. II.

IV. Nitric acid, when recently prepared, is a transparent and colourless liquid like water. Its taste is exceeding acrid. It corrodes rapidly animal substances of all kinds. When applied to the skin, it stains that membrane of an indelible yellow colour. It constantly emits white fumes, which have an acrid and disagreeable odour. It is very readily decomposed; even the action of light will cause it to evolve oxygen gas, and to form deutoxide of azote, whereby it assumes a yellow colour. Its properties.

V. Nitric acid has never been obtained perfectly free from admixture of water. When as much concentrated as possible, it is about one and a half times as heavy as water. When its specific gravity is 1·42, its boiling point is at the temperature of 248°. If it be more or less concentrated, its boiling point is lower. When exposed to the temperature of —66°, it begins to congeal; and, if agitated, is converted into a mass of the consistence of butter. The fact, that nitric acid has never been obtained free from water, proves the strong affinity which it has for this liquid. It attracts moisture from the atmosphere; but not with the same avidity as sulphuric acid does. Always contains water. Spec. grav. 1·55.

VI. Nitric acid is capable of combining with oxygen, as Thenard has lately discovered. This chemist obtained the oxidized acid in the following manner:—Peroxide of barium was first moistened with water, so as to make it fall to powder, and then mixed with seven or eight times its weight of water. Diluted nitric acid was now added to the mixture: no gas was evolved, and the solution was found to be neutral. Upon adding sulphuric acid to the solution, sulphate of barytes was immediately precipitated; and the second dose of oxygen of the peroxide, instead of being evolved, was transferred to the nitric acid. After the insoluble sulphate was removed, the remaining liquid proved to be an oxidized nitric acid. Oxynitric acid is a colourless liquid. It is capable of reddening vegetable blues. It possesses most of the properties of nitric acid. When heated, it parts with its oxygen, but not completely, unless after being kept boiling for a considerable time. It was concentrated so far, by Thenard, as to contain eleven times its bulk of oxygen. It combines with some of the salifiable bases, with which it forms very decomposable, non-crystallizable salts.* May be oxidized to various degrees.

* The facts above given, respecting oxynitric acid, were taken from a translation of Thenard's paper, in the Annals of Philosophy.

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Action of combustibles upon nitric acid.

VII. Nitric acid is decomposed by all the combustibles, except the diamond, gold, platinum, palladium, rhodium, and columbium. It is not affected by hydrogen, at the common temperature of the air; but, if passed along with this combustible, through a red-hot porcelain tube, a violent detonation takes place; water is formed, and azote evolved. When poured upon charcoal, perfectly dry and minutely divided, it is decomposed with such rapidity, that the charcoal is instantly inflamed. In like manner, it inflames phosphorus and sulphur, at high temperatures. When poured upon perfectly dry iron filings, it parts with its oxygen so suddenly, as to set them on fire. The same effect is produced, when the acid is poured upon zinc, tin, or bismuth, in a state of fusion. When poured upon drying oils, it sets them on fire instantaneously. The same effect is produced upon other oils, provided a little sulphuric acid be first added to them.

Nitric acid absorbs deutoxide of azote.

VIII. Nitric acid has the property of absorbing deutoxide of azote (nitrous gas), in different proportions. This combination was formerly called phlogisticated nitric acid. When the gas is placed in contact with the acid, the latter becomes at first a pale yellow, then a bright yellow. After a considerable quantity of the gas is absorbed, the acid becomes dark-orange, then olive, which colour increases in intensity, as the absorption proceeds. The next colour, which appears, is bright-green; and lastly, when fully saturated, it is blue-green.

It is decomposed, when mixed with hydrochloric acid.

IX. When nitric acid is mixed with hydrochloric (muriatic) acid, a decomposition instantly takes place, and the odour of chlorine becomes perceptible. Part of the nitric acid is decomposed into deutoxide of azote (nitrous gas) and oxygen. The deutoxide of azote remains in solution in the acid; the oxygen combines with the hydrogen of the hydrochloric acid, while the chlorine of the latter is evolved. The mixture of nitric and hydrochloric acids was formerly called aqua regia.

X. When nitric acid is poured upon iodic acid, in a concentrated state, white crystals are deposited, which, upon drying, are partly sublimed, and partly decomposed into iodine, oxygen, and nitric acid.

It forms nitrates with bases.

XI. Nitric acid combines with the different salifiable bases, and forms a set of salts called nitrates. These salts will be described under the heads of their respective bases.

Composition.

XII. Nitric acid is composed of

Azote	14—one atom.
Oxygen	40—five atoms.

Giving 54 for the number representing the weight of its atom.

XIII. Priestley and Lavoisier made the preparatory investigations, which led to the discovery of the constituents of nitric acid. Lavoisier had suspected, from an experiment, in which he decomposed nitrate of potash (nitre) by charcoal, that the base of nitric acid is azote. Several of Dr. Priestley's experiments seemed to show the same thing. But its particular constituents were not absolutely demonstrated, before Cavendish made his celebrated experiment of forming nitric acid, by passing repeated shocks of electricity, through a mixture of oxygen and azotic gases.

Account of the discovery of its constituents.

XIV. Nitric acid, in a state of vapour, has been employed to destroy the contagion, or noxious effluvia, with which jails, hospitals, ships, and over-crowded places, are liable to become infected. The manner, in which it is employed, is to put half an ounce of nitrate of potash (nitre) in a saucer, placed in an earthen vessel, filled with heated sand. To the nitrate of potash, two drams of sulphuric acid are to be added; which decomposes the nitrate, the nitric acid flying off in a state of vapour. The nitric fumes, from the decomposition of half an ounce of nitrate of potash, are calculated to be sufficient to fill a cube of ten feet. The application of nitric acid vapour, to the purposes of purifying infected apartments, was first made by Dr. Carmichael Smyth; who received for his discovery, from the British government, a reward of five thousand pounds.

Nitric acid vapour useful for destroying contagion, and noxious effluvia.

XV. Nitric acid constitutes an important article of the materia medica. Its action appears to be that of a very powerful stimulant. It has been used, with advantage, in low typhus fevers. In the venereal disease, when combined with deutoxide of azote (nitrous gas), under the form of what is commonly called nitrous acid, it has been used with unequivocal advantage. It has suspended all the symptoms of that disease, whether of its first or second stage; and, in some cases, they have not returned. It cannot, however, be depended upon as a remedy in syphilis; but as an auxiliary means in its treatment, in some cases, it is of indispensable importance. These cases are such, in which, from an impaired constitution, mercury cannot be resorted to at once. Here then the acid removes the more alarming symptoms, increases the strength of the system, and thereby prepares the way for the subsequent exhibition of mercury.

Nitric acid, an important medicine.

SECTION II.

OF NITROUS ACID.

Nitrous acid; how obtained pure.

I. NITROUS ACID may be obtained by distilling perfectly dry nitrate of lead in a retort, fitted with a receiver. A liquid comes over, which is nitrous acid.

II. Nitrate of lead is composed of nitric acid and protoxide of lead. When it is exposed to heat, the lead becomes peroxidized at the expense of the acid, which distils over in the form of nitrous acid.

Discovered by Scheele.

III. This acid was discovered by Scheele. This chemist found, that, when nitrate of potash (nitre) was exposed, for a certain time, to a red heat, a quantity of oxygen was extricated; yet the neutral properties of the salt were not altered. If acetic acid be poured upon this salt, vapours of nitrous acid are evolved.

Properties.

IV. Nitrous acid is an orange-coloured, very volatile, fuming liquid. Its taste is very sour. When mixed with water, an effervescence ensues, and deutoxide of azote (nitrous gas) is extricated. It, therefore, appears incapable of uniting with water.

Spec. grav. 1·451.

V. It is somewhat less than one and a half times as heavy as water. Its boiling point is at the temperature of 82°.

VI. It combines with many of the salifiable bases, and forms a set of salts called nitrites. These salts will be described under the heads of their respective bases.

Composition.

VII. Nitrous acid is composed of

Azote	14—one atom.
Oxygen	32—four atoms.
	46

Giving 46 for the number representing the weight of its atom.

SECTION III.

OF HYPONITROUS ACID.

Hyponitrous acid; its existence rendered probable by Gay-Lussac.

I. GAY-LUSSAC has made it probable, from his experiments, that there is another compound of azote and oxygen, possessing acid properties, which contains less oxygen than nitrous acid. To this combination he gives the name of pernitrous acid. The name adopted here is that proposed

by Dr. Thomson. This compound has never been obtained in a separate state; neither is it known whether it is capable of combining with salifiable bases. Chap. II.

II. It appears to be composed of

Azote	14	—one atom.
Oxygen	24	—three atoms.
	38	

Giving 38 for the number representing its atom.

Carbon forms but one acid by combining with oxygen; namely, carbonic acid. This acid is described in the following section. Carbon forms but one acid with oxygen.

SECTION IV.

OF CARBONIC ACID.

Syn. *Fixed Air.—Aerial Acid.—Mephitic Acid.—Calcareous Acid.*

I. Carbonic acid may be obtained by pouring sulphuric acid upon a quantity of chalk, mixed with water. An effervescence takes place, and a gas is extricated: this gas is carbonic acid. Carbonic acid; how obtained.

II. Chalk is a compound of the acid under description and lime. The sulphuric acid poured upon it combines with the lime, and displaces the carbonic acid, which flies off in the form of gas.

III. Carbonic acid is a gaseous fluid, invisible and elastic like common air. It is destitute of smell. It reddens tincture of turnsol, but no other vegetable colour. It is not altered by exposure to heat in close vessels, or by being passed through a red-hot tube. Its properties.

IV. It is a little more than one and a half times as heavy as common air. Its weight is sufficient to admit of its being poured from one vessel to another. Spec. grav. 1·527.

V. Carbonic acid does not support combustion. When a lighted candle is plunged into the gas, it is immediately extinguished. The same effect is produced when the gas is poured upon a burning body. It is not fit for supporting respiration.

VI. At the temperature of 55°, water absorbs a little more than its bulk of this gas, and suffers a small increase in its specific gravity. At the temperature of 35°, liquid carbonic acid has no taste; but at 88°, it becomes sparkling; Absorbable by water.

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and agreeably acid. Ice is not capable of absorbing this gas; and if water, saturated with it, is either frozen or boiled, the whole of the gas is separated.

By artificial pressure, water may be easily made to take up six times its bulk of this gas, or even a much larger quantity. Water, when thus impregnated, and a portion of carbonate of soda dissolved in it, constitutes the soda water, which is so largely drunk, in the summer season, in the cities of the United States.

Action of combustibles.

VII. The undecompounded supporters do not appear to have any action upon carbonic acid. Of the combustibles, charcoal, at a red heat, robs it of part of its oxygen, and converts it into carbonic oxide. Phosphorus is capable of decomposing this acid when combined with lime, by means of heat; phosphoric acid is formed, which combines with the lime, and charcoal is deposited.

Combines with bases, and forms carbonates.

VIII. Carbonic acid combines with salifiable bases, and forms a set of compounds called carbonates. These salts will be described under the heads of their respective bases.

Composition.

IX. Carbonic acid is composed of

Carbon	6—one atom.
Oxygen	16—two atoms.
Giving	22 for the number representing

the weight of its atom.

Carbonic acid, known to Hales:

X. The nature of carbonic acid was gradually ascertained by the successive labours of chemists. Hales had noticed that a certain air could be separated from limestone and similar substances, and that it was one of their constituents. The bare fact of its existence was all that was known concerning it, before the discoveries of Black. This chemist ascertained, that it existed in chalk, in common magnesia, and in common potash and soda; and that these substances, in their caustic state, were deprived of their causticity, by combining with this air. As it became fixed in these bodies, under certain circumstances, he gave it the name of fixed air. After Black, Cavendish and Priestley made experiments upon the air, and ascertained many of its properties. Kier was the first to ascribe to it acid properties; which were afterwards proved to belong to it by Bergman and Fontana. Bergman adopted the opinion of Priestley, that it was an element of atmospheric air, and called it aerial acid. From its occasioning death when respired, Bewdley called it *mephitic acid.*

ascertained by Black to deprive potash, soda and lime of their causticity, by combining with them.

By the labours of the chemists just mentioned, the more important properties of fixed air were ascertained. But the important question was yet to be answered; was it to be considered a compound or an elementary substance?

Priestley and Bergman, at first, appear to have considered it an elementary substance; while some other chemists accounted it an acidifying principle. As soon as its compound nature was ascertained, and that oxygen was one of its constituents, the general belief was, that it was a compound of oxygen and phlogiston; and when hydrogen (according to Kirwan) came to signify the same thing as phlogiston, of oxygen and hydrogen.

Supposed, by some chemists, to be an elementary substance:

While the opinions of chemists were thus vacillating, as to the real nature of fixed air, Lavoisier succeeded in proving its constituents to be oxygen and carbon. It was this chemist who gave it the name of carbonic acid, from the name of its base.

proved by Lavoisier to be composed of oxygen and carbon.

Boron forms but one acid with oxygen; namely, boracic acid. This acid is described in the following section.

Boron forms but one acid with oxygen.

SECTION V.

OF BORACIC ACID.

Sedative or Narcotic Salt of Homberg.

I. Boracic acid may be obtained by dissolving borax in hot water, filtering the solution, and afterwards precipitating it, by means of sulphuric acid, added in excess. A crystallized precipitate falls, which, when washed, and dried on filtering paper, is boracic acid in the state of hydrate.

Boracic acid; how obtained.

II. Borax is a compound of boracic acid and soda. When sulphuric acid is added to its solution, it is decomposed; sulphate of soda is formed, and boracic acid, precipitated.

III. Boracic acid has heretofore been found only in borax, in a state of combination with soda.

Exists only in borax.

IV. Boracic acid was discovered, in 1702, by Homberg, by whom it was called sedative or narcotic salt, while distilling a mixture of green vitriol and borax. Homberg was not aware of its real nature; and it was not until about 50 years afterwards, that its acid properties were ascertained, when it was named boracic acid.

Discovered by Homberg.

The discovery of its compound nature and constituents, by Gay-Lussac and Thenard, and Davy, has already been noticed under the head of boron.

V. Boracic acid, as obtained by the process given in the first paragraph, is a solid, in the form of scales, of a silver-

Properties.

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white colour. It has a greasy feel, and has some resemblance to spermaceti. Its taste is somewhat sour at first; it then becomes bitterish and cooling, and at last agreeably sweet. After being heated to redness, however, it loses its sour taste. It has no smell; but the addition of sulphuric acid to it, produces a transient odour of musk. Vegetable blues are changed to red by its action.

Spec. grav. 1·479.

VI. It is somewhat less than one and a half times as heavy as water. It is perfectly fixed in the fire. Its melting point is at a red heat. By fusion, it is converted into a hard transparent glass, which becomes somewhat opaque by exposure to air. In this state, its specific gravity is 1·803.

VII. Boiling water scarcely dissolves the $\frac{1}{50}$th part of its weight of boracic acid; and cold water, a still smaller quantity. When this solution is distilled in close vessels, part of the acid comes over with the water. Hence, although extremely fixed in the dry state, when in solution, it is somewhat volatile.

Action of combustibles.

VIII. None of the undecompounded supporters exert any action upon boracic acid. Of the undecompounded combustibles, the only ones, which appear capable of decomposing it, are potassium and sodium.

IX. Boracic acid combines with many of the salifiable bases, forming salts called borates.

X. The exact composition of boracic acid has not been well made out. The analyses of Gay-Lussac and Davy are so discordant, as to forbid any confidence being placed in either.

Boracic acid, formerly used in medicine.

XI. Boracic acid was considered by its discoverer, Homberg, to be a very efficacious remedy in continued fevers; and, for a long time, it enjoyed considerable reputation, in France, for the cure of this class of diseases. At the present day, although an article of some power, it is very seldom employed.

Phosphorus forms three acids with oxygen.

Phosphorus forms three acids by combining with oxygen; namely, phosphoric acid, phosphorous acid, and hypophosphorous acid. These acids will be described in the three following sections.

SECTION VI.

OF PHOSPHORIC ACID.

Phosphoric acid; how obtained.

I. Phosphoric acid may be obtained by the following process: Mix the liquid, obtained by the slow combustion of phosphorus, with nitric acid, allow the mixture to stand

for a few days, and then evaporate it to dryness. The dry mass is phosphoric acid in the state of hydrate. Chap. II.

II. When phosphorus is subjected to slow combustion, a liquid is formed, which is a mixture of phosphorous and phosphoric acids. When this liquid is mixed with nitric acid, the phosphorous acid is further oxidized at the expense of the nitric acid; so that the whole becomes phosphoric acid. The mixture is then exposed to a drying heat, in order to drive off any adhering nitric acid.

It is present in bones.

III. The most abundant source in nature of phosphoric acid is the bones of animals.

Its properties.

IV. Phosphoric acid is a solid substance, sometimes transparent, when it has considerable resemblance to glass. Usually, however, it is not perfectly clear, but possesses a degree of milkiness. It possesses a very sour taste, but no smell. It changes vegetable blues to a red colour. It does not possess corrosive properties. When exposed to the air, it absorbs moisture, and deliquesces into a thick, oil-like liquid.

Spec. grav. 2·687.

V. Phosphoric acid is a little more than two and two-third times as heavy as water. When exposed to a red heat, it melts into a transparent liquid, which, upon cooling, assumes the appearance of glass. In this state, it is known by the name of phosphoric glass: it is phosphoric acid, nearly, if not entirely, deprived of water. Phosphoric glass is about three times as heavy as water.

Soluble in water.

VI. Phosphoric acid dissolves, very readily, in water. When in the form of a dry acid, the solution takes place with a hissing noise, resembling that produced by red hot iron, when plunged into water. In the form of glass, it is much less soluble. These solutions are attended by the evolution of some heat. The deliquesced acid is a solution of phosphoric acid. It is in this state that it is generally employed by chemists. Its specific gravity is 1·417.

Action of combustibles.

VII. Of the undecompounded combustibles, carbon, potassium, sodium, iron, zinc and tin, are capable of decomposing phosphoric acid; these bodies being oxidized, and phosphorus developed. The liquid acid oxidizes antimony, iron, manganese, zinc, lead, tin and bismuth; but some of these metals, very slowly. The oxidizement of the latter metals, takes place in consequence of the decomposition of water; as is evinced by the evolution of hydrogen. It has no action upon arsenic, nickel, cobalt, copper, silver, mercury, gold, or platinum.

VIII. Phosphoric acid combines with most of the salifiable bases, forming salts called phosphates. These salts will be described under the heads of their respective bases.

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Composition.

IX. Phosphoric acid is composed of

Phosphorus	12—one atom.	
Oxygen	16—two atoms.	

Giving 28 for the number representing the weight of its atom.*

Discovery of composition.

X. Phosphoric acid had been for a long time known, before its composition was ascertained. Stahl considered it to be the same with hydrochloric (muriatic) acid; which acid, in combination with phlogiston, or the inflammable principle, he supposed to form phosphorus. Margraff ascertained that it was different from all other acids; but still it was considered to be a constituent in phosphorus.

The composition of phosphoric acid was supposed to be perfectly well understood, when Lavoisier published his experiments on the acids; whereby he overturned the prevailing phlogistic doctrines, and demonstrated the true composition of this acid.

SECTION VII.

OF PHOSPHOROUS ACID.

Phosphorous acid; how obtained.

I. Phosphorous acid may be obtained by the following process: Sublime phosphorus through pulverized perchloride of mercury (corrosive sublimate) contained in a glass tube: a chloride of phosphorus will be formed, and the mercury revived. Upon mixing this chloride with water, it will be converted into hydrochloric (muriatic) acid and phosphorous acid, by combining with the constituents of this liquid. Evaporate the mixed acids, until the whole become of the consistence of syrup: the evaporation will drive off the hydrochloric acid; whereby the phosphorous acid will be obtained pure.

Liquid obtained by the slow combustion of phosphorus, a mixed acid.

II. The acid, obtained by the slow combustion of phosphorus, was formerly called phosphorous acid. But this acid is now ascertained to be a compound of phosphoric acid, and the acid, described, in the present section, as the phosphorous acid. Dulong, considering it to be composed of the two acids, just mentioned, united in a fixed proportion, has applied to it the name of phosphatic acid.

III. Phosphorous acid was first obtained, in a pure state, by Sir H. Davy.

* This composition is given on the authority of some late results, obtained by Sir H. Davy. See Annals of Philosophy, p. 210. (March, 1819); or Sir H. Davy's paper, Phil. Trans. 1818. part II.

IV. Phosphorous acid is a solid substance, possessing a very sour taste. It reddens vegetable blues, and has all the characters of a strong acid. When heated strongly in the open air, it catches fire and emits abundance of hydroguret of phosphorus (phosphuretted hydrogen); the residue being phosphoric acid. Chap. II. Properties of phosphorous acid.

V. Phosphorous acid combines with some of the salifiable bases, forming salts called phosphites.

VI. Phosphorous acid is composed of Its composition.

Phosphorus	12—one atom.
Oxygen	8—one atom.

Giving 20 for the number representing the weight of its atom.*

SECTION VIII.

OF HYPOPHOSPHOROUS ACID.

I. Hypophosphorous acid may be obtained by the following process: Allow phosphuret of barytes to remain in water, as long as it gives out any gas. The water will be decomposed; its hydrogen, by combining with part of the phosphorus, gives rise to the formation of hydroguret of phosphorus, the gas, which is extricated; while its oxygen combines in two proportions with the remaining phosphorus, so as to form the acid under description and phosphoric acid. Both these acids, as soon as formed, combine with the barytes. Now phosphate of barytes is insoluble, while the hypophosphite dissolves in water: accordingly, upon filtering the liquid, the phosphate of barytes will be removed, and nothing will be left, but a solution of hypophosphite of barytes. Add cautiously to this solution, sulphuric acid, as long as any precipitate should appear: this acid will form an insoluble compound with the barytes, and thereby liberate the hypophosphorous acid from combination. Separate the insoluble sulphate of barytes, and what remains will be a solution of hypophosphorous acid. Hypophosphorous acid; how obtained.

II. Hypophosphorous acid was discovered in 1816 by Dulong.

III. Hypophosphorous acid, in the state of solution, has a very sour taste, and possesses the property of reddening Its properties.

* This composition accords with a late result obtained by Sir H. Davy. See a notice of this chemist's paper (published in the Philosophical Transactions for 1818), in Thomson's Annals, p. 210. (March 1819).

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vegetable blues. It absorbs oxygen from the atmosphere. When exposed to heat, it is totally decomposed; hydroguret of phosphorus (phosphuretted hydrogen) being evolved, and phosphoric acid remaining behind. It may be concentrated by evaporation, so as to assume the form of a viscid liquid; but it cannot be made to crystallize.

Composition.

IV. According to Sir H. Davy, hypophosphorous acid is composed of

Phosphorus	24—two atoms.
Oxygen	8—one atom.
	32

Giving 32 for the number representing the weight of its atom.*

Arsenic forms two acids with oxygen.

Arsenic forms two acids by combining with oxygen; namely arsenic acid and arsenious acid. These acids will be described in the following sections.

SECTION IX.

OF ARSENIC ACID.

Arsenic acid; how obtained.

I. Arsenic acid may be formed by the following process: dissolve three parts of arsenious acid (white oxide of arsenic) in seven parts of hydrochloric (muriatic) acid; and mix the solution with five parts of nitric acid: the arsenious acid becomes converted into arsenic acid, at the expense of the oxygen of the nitric acid. Evaporate the whole to dryness and then expose it to a red heat: the nitric and hydrochloric acids will be driven off, and the arsenic acid obtained pure.

Its properties.

II. Arsenic acid, when thus prepared, is a white substance; possessing scarcely any taste when dry. It attracts moisture from the atmosphere. It is not volatile; but when exposed to a sufficient heat, it melts into a transparent liquid, which has the appearance of glass, when cold. If the heat be very strong, it gives out some oxygen, and is converted into arsenious acid, which exhales the garlic odour.

Spec. grav. 3·39.

III. Arsenic acid is about three and one-third times as heavy as water. It dissolves slowly in six parts of cold water; but instantly in two parts of boiling water. In a state of solution, its taste is acrid, caustic and metallic. It may

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* For this composition, see Annals of Philosophy, p. 210 (March 1819,) or Sir H. Davy's paper on the compounds of phosphorus with oxygen, published in the Philosophical Transactions, part II. (1818.)

be evaporated to the consistence of a syrup. In this form, it contains half its weight of water. CHAP. II.

IV. Arsenic acid oxidizes arsenic, antimony, iron, nickel, cobalt, manganese, zinc, lead, tin, copper and bismuth; and in a strong heat, mercury and silver. It does not act upon gold or platinum. Its action on metals.

V. Arsenic acid combines with many of the salifiable bases, and forms salts called arseniates. These salts will be described hereafter.

VI. Arsenic acid is composed of Composition.

Arsenic	46—	
Oxygen	24—	three atoms.
	70	

VII. Arsenic acid is one of the most virulent poisons known. It is equally deleterious with arsenious acid. It is not used in medicine. Is a virulent poison.

SECTION X.

OF ARSENIOUS ACID.

Oxide of Arsenic of the Edinburgh College. Common names, *Arsenic. White Arsenic.*

I. ARSENIOUS ACID may be formed by exposing metallic arsenic to heat, in the open air. The metal sublimes in the form of this acid. Arsenious acid; how obtained.

II. Arsenious acid is obtained, for the purposes of commerce and the arts, during the extraction of cobalt from its ores. These ores contain arsenic. During their roasting, arsenious acid, in an impure state, sublimes. The impure acid is afterwards purified by a subsequent sublimation, mixed with potash. How obtained in the large way.

III. Arsenious acid is a white, brittle, compact solid, of a vitreous appearance. Its taste is sharp and acrid, accompanied by an impression of sweetness. It changes vegetable blues to red. When heated, it emits fumes, which have a smell, resembling that of garlic. If a plate of copper be exposed to these fumes, it becomes white. Its properties.

IV. Arsenious acid is about three and three-fourths as heavy as water. When heated to the temperature of 283° in the open air, it may be entirely sublimed. Hence, a very obvious means is afforded for the detection of adulterating substances, such as carbonate of lime (chalk) or sulphate of lime (gypsum). When subjected to heat, in close vessels, it melts into a pellucid glass, which soon becomes opaque by exposure to the air. Spec. grav. 3·70.

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V. Arsenious acid is soluble in 80 parts of cold water; but it dissolves in 15 parts of boiling water. In the state of solution, the acid has an acrid taste, and changes vegetable blues to a red colour. When slowly evaporated, the acid falls in the form of crystals.

Dissolves in water.

VI. Arsenious acid combines with some of the salifiable bases, forming salts called arsenites. Some of these salts will be described hereafter.

Its composition.

VII. Arsenious acid is composed of

Arsenic	47—one atom.
Oxygen	16—two atoms.
	—

Giving 63 for the number representing the weight of its atom. The weight of an atom of arsenic, however, as deduced from this acid, is somewhat higher than when calculated from the arsenic acid. The proportions, in which arsenic combines with other bodies, do not accord well with the atomic theory.

Arsenious acid, a violent poison.

VIII. Arsenious acid is one of the most virulent poisons known. When taken into the stomach, or applied to a wounded part, it gives rise to a train of the most terrible symptoms, to which the human system is liable.

Its antidote.

IX. A number of experiments have been made to ascertain the best antidote for the arsenious acid. It has been found, that, of all the substances tried, liquid hydrosulphuric acid (sulphuretted hydrogen) promises to be the most effectual. Hydrosulphuric acid combines readily with arsenious acid, and forms a compound, which may be taken, in tolerably large doses, with impunity.

Treatment of a case of poisoning by arsenic.

When a case of poisoning by the arsenious acid is to be treated; the first step is to encourage vomiting, by giving large draughts of warm water, and by irritating the fauces with a feather. No emetic substances are to be used to produce this effect; as they add to the irritation. After the vomiting has ceased, it is next proper to wash out the stomach repeatedly with water, injected into that organ, through a gum elastic catheter, and returned again through the same instrument. After these measures have been carried fully into execution, liquid hydrosulphuric acid is to be administered in as large quantities as can be taken.*

Uses of arsenious acid in medicine.

X. Arsenic is sometimes exhibited in the form of a solution of arsenious acid. Four grains of the acid are dissolved in a pint of water. The dose is a tablespoonful, gradually increasing. In this form, it has been exhibited in

* For a full account of the arsenical poisons, see Nancrede's Abridgment of Orfila on Poisons; the work from which the above facts have been taken.

cancer. It has also been used, both in powder and in solution, as an external application to cancerous sores. The arsenious acid, in substance, is given in the form of pills, in doses of about one-eighth of a grain. *Chap. II.*

Chromium forms but one acid with oxygen; namely, chromic acid. This acid will be described in the following section. *Chromium forms one acid with oxygen.*

SECTION XI.

OF CHROMIC ACID.

I. Chromic acid may be obtained by the following process: Roast a mixture of one part of nitrate of potash (nitre) and two parts of the mineral called chromate of iron, in a hessian crucible. Treat the mass with water, until every thing soluble be taken up. By this management, part of the mineral becomes decomposed; the chromic acid of the decomposed portion combines with the potash of the nitrate of potash; and, in this state of combination being soluble, when the mass is treated with water, it is dissolved off, while the undissolved residue consists of oxide of iron and undecomposed chromate. Dissolve off the oxide of iron by means of hydrochloric acid, and repeat the treatment already detailed, upon what remains. By these measures the mineral will at last be totally decomposed. When this is effected, mix all the solutions of chromate of potash together; and saturate the liquid formed, with acetic acid, and then evaporate it, until it let fall crystals of chromate of potash. Dissolve these crystals in water, and add to the solution formed, chloride of barium (muriate of barytes): the chromic acid immediately falls in combination with barytes. Wash the chromate of barytes, thus obtained; and, having dissolved it in nitric acid, add sulphuric acid cautiously to the solution: the sulphuric acid falls in combination with the barytes, while the chromic acid remains in solution along with the nitric acid. Remove the insoluble sulphate of barytes by the filter, and evaporate the remaining liquid to dryness, at a low red heat: this exposure to heat will drive off the greater part of the nitric acid. By solutions and evaporations, repeated several times, the whole of the nitric acid may be removed. What remains will then be pure chromic acid. *Chromic acid; how obtained.*

II. Chromic acid was discovered, in 1797, by Vauquelin, in chromate of lead (red lead ore of Siberia). *Discovery.*

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Its properties.

III. Chromic acid is a solid substance, of a deep red colour. Its taste is acrid, sharp, and strongly metallic. It slowly absorbs moisture, when exposed to the air. When subjected to heat, it gives out oxygen gas, and is converted into protoxide (green oxide) of chromium. It is soluble in water, and may be obtained, from the solution, in crystals of a ruby-red colour.

IV. Chromic acid combines with several of the salifiable bases, and forms salts called chromates.

Composition.

V. Chromic acid is composed of

Chromium	28—one atom.
Oxygen	24—three atoms.
	52

Giving 52 for the number representing the weight of its atom.

Molybdenum forms two acids with oxygen.

Molybdenum forms two acids by combining with oxygen; namely, molybdic acid and molybdous acid. These acids will be noticed in the two following sections.

SECTION XII.

OF MOLYBDIC ACID.

Molybdic acid; how obtained.

I. Molybdic acid may be obtained by the following process: Distil nitric acid off the mineral called molybdena (sulphuret of molybdenum) reduced to the state of powder: the nitric acid, by yielding up its oxygen, will acidify the molybdenum, and, in part, the sulphur; so that after the distillation is completed, the mass obtained will consist of molybdic acid, mixed with sulphuric acid and some adhering nitric acid. By washing the mass carefully with water, the sulphuric and nitric acids will be removed; so that nothing will remain but pure molybdic acid.

II. Molybdic acid was discovered, in 1778, by Scheele.

Its properties.

III. Molybdic acid is in the form of a white powder. When subjected to heat, in close vessels, it melts, and assumes the form of crystals upon cooling; but in open vessels, it sublimes in the form of brilliant yellow scales.

IV. Molybdic acid is soluble in 960 parts of boiling water. The solution has a yellow colour, but no taste. It is capable of reddening vegetable blues. The acid is precipitated, from the solution, by sulphuric, nitric, or hydrochloric acid.

V. Molybdic acid combines with some of the salifiable bases, forming salts called molybdates. Chap. II.

VI. Molybdic acid is composed of Composition.

Molybdenum	48—one atom.
Oxygen	24—three atoms.
	—

Giving 72 for the number representing the weight of its atom.

SECTION XIII.

OF MOLYBDOUS ACID.

I. Molybdous acid may be obtained by the following process: Triturate, in a porcelain mortar, a mixture of one part of molybdenum, with two parts of molybdic acid, made into a pap with a little hot water, until the whole assume a blue colour. Then add eight or ten parts of water, and boil for a few minutes. Filter the liquid obtained, and evaporate it to dryness, at a heat not exceeding 120°. The dry mass will be molybdous acid. Molybdous acid; how obtained.

II. Molybdous acid is in the form of a blue powder, soluble in water. It has the property of converting vegetable blues to red. It combines with salifiable bases, forming salts called molybdites. Its properties.

III. Molybdous acid is composed of Composition.

Molybdenum	48—one atom.
Oxygen	16—two atoms.
	—

Giving 64 for the number representing the weight of its atom.

Tungsten forms but one acid by combining with oxygen; namely, tungstic acid. This acid will be described in the following section. Tungsten forms one acid with oxygen.

SECTION XIV.

OF TUNGSTIC ACID.

I. Tungstic acid may be obtained by the following process: Boil three parts of hydrochloric (muriatic) acid upon one part of the mineral, called wolfram (tungstate of iron) for several hours; and allow it to stand until it de- Tungstic acid; how obtained.

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posite a powder. Separate the powder by the filter, and dissolve it in ammonia. Evaporate the ammoniacal solution to dryness, and expose the dry mass to a red heat. The dry mass is now pure tungstic acid. It was discovered, in 1781, by Scheele.

Its properties.

II. Tungstic acid is an insoluble yellow powder, incapable of acting on vegetable blues. It, however, possesses the essential property of an acid, of forming salts with the salifiable bases.

Composition.

III. Tungstic acid is composed of

Tungsten	96—one atom.
Oxygen	24—three atoms.

Giving 120 for the number representing the weight of its atom.

Columbium forms but one acid with oxygen.

Columbium forms but one acid by combining with oxygen; namely, columbic acid. This acid will be noticed in the following section.

SECTION XV.

OF COLUMBIC ACID.

Columbic acid; how obtained.

I. Columbic acid may be formed by detonating a mixture of pulverized columbium and nitrate of potash (nitre), in a red-hot crucible. The nitric acid of the nitrate acidifies the columbium, and then is dissipated; so that the resulting mass is a mixture of columbic acid and potash. Dissolve the mass in water, and add, to the solution, hydrochloric (muriatic) acid: this acid combines with the potash and remains in solution, while the columbic acid falls in the state of hydrate.

II. Columbic acid was discovered, and its acid nature ascertained, by Hatchett, in 1801.

Its properties.

III. Columbic acid is in the form of a white powder, insoluble in water, nitric or sulphuric acid. It combines with some of the salifiable bases, and forms salts called columbates.

Composition.

IV. Columbic acid is composed of

Columbium	146—one atom.
Oxygen	8—one atom.

Giving 154 for the number representing the weight of its atom.

Antimony forms two acids by combining with oxygen; namely, antimonic acid, and antimonious acid. These acids will be described in the two following sections. Antimony forms two acids with oxygen.

SECTION XVI.

OF ANTIMONIC ACID.

I. Antimonic acid may be obtained by the following process: Expose a mixture of one part of antimony in powder, and six parts of nitrate of potash (nitre) for an hour, in a silver crucible, to as strong a heat as the vessel will bear: the mass formed will be found to be a mixture of antimonic acid, potash, and undecomposed nitrate of potash. Wash off the two latter with water; and digest the insoluble residue in hydrochloric (muriatic) acid, in order to be certain that all the potash is removed. After this treatment, dry it, and expose it to a sufficient heat to drive off all the water, which it may contain. What remains is pure antimonic acid. Antimonic acid; how obtained.

II. Antimonic acid is a straw-coloured powder. It is insoluble in water, and does not redden vegetable blues, unless it be in the state of hydrate. When heated to redness, part of its oxygen is disengaged, and it is converted into antimonious acid. Its combinations with salifiable bases are called antimoniates. As yet no analysis of this acid has been made that can be depended upon. Its properties.

III. The medicinal preparation, formerly called diaphoretic antimony, the calcined antimony of the London college, consists of antimonic acid, combined with one-fifth of its weight of potash. It is formed pretty much in the manner just given for the acid itself; with these slight differences that the sulphuret of antimony, instead of the pure metal, is employed, and the product is not washed with hydrochloric acid, to separate adhering potash. Nature of diaphoretic antimony.

SECTION XVII.

OF ANTIMONIOUS ACID.

(Formerly called *Argentine Flowers of Antimony.*)

I. Antimonious acid may be obtained by dissolving antimony in nitric acid, evaporating the solution to dryness, and exposing the dry mass to a red heat. It may be formed Antimonious acid; how obtained.

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also by subjecting protoxide of antimony to a red heat, or metallic antimony to a violent heat. In either case, combustion takes place, and antimonious acid sublimes in the form of crystals. When procured by sublimation, the acid was formerly called argentine flowers of antimony.

Its properties.

II. Antimonious acid is a powder, possessing a fine white colour and considerable lustre. It is insoluble in water, and dissolves with difficulty in acids. It requires a pretty high temperature to produce its fusion; but it is volatilized at a point comparatively low. Its combinations with salifiable bases are called antimonites. It has not been analyzed with precision.

CLASS III.

ACIDS, WHOSE BASES FORM ACID COMPOUNDS BY COMBINING WITH HYDROGEN ONLY.

Two acids only belong to the third class of acids.

Two acids only are known, belonging to this class: namely, hydrofluoric acid, and hydrocyanic acid. The former has an undecompounded base (fluorine), the latter a compound base (cyanogen). These acids will be described in the two following sections.

SECTION I.

OF HYDROFLUORIC ACID.

Usual chemical name, *Fluoric Acid.*

Hydrofluoric acid; how obtained.

I. Hydrofluoric acid may be obtained by the following process: Distil, with a gentle heat, from a leaden retort into a leaden receiver, any quantity of pure white fluor spar, which is a hydrofluate (fluate) of lime, with twice its weight of concentrated sulphuric acid. The receiver must be surrounded with a mixture of snow and salt, and the joinings of the apparatus, luted with clay. The product of the distillation will be hydrofluoric acid.

Process explained.

II. The mineral called fluor spar is a compound of hydrofluoric acid and lime. When it is mixed with sulphuric acid, it becomes decomposed; this acid combines with the lime, and the hydrofluoric acid is disengaged in the form of vapour, which afterwards condenses in the refrigerated receiver. Glass vessels could not be employed in the apparatus; since they would be corroded by the hydrofluoric

acid. The same objection does not apply to leaden vessels; these not being acted upon by the acid. Chap. II.

III. Hydrofluoric acid was first obtained pure, in 1808, by Gay-Lussac and Thenard; by whom the process, above described, was invented. The acid, previously considered to be the acid of fluor spar, was ascertained by them to contain silica as an essential ingredient. This acid first obtained pure by Gay-Lussac and Thenard.

IV. Hydrofluoric acid, at the temperature of 32°, is a colourless liquid. At the temperature of 60°, it still continues a liquid. Its smell is similar to that of hydrochloric acid, but much stronger. When exposed to the open air, it fumes violently, and is entirely dissipated. It can only be preserved in metallic vessels; glass vessels are instantly corroded by it. It acts with great energy upon animal substances of all kinds. When dropped upon the skin, it acts as a powerful escharotic. The fumes of the acid, when inhaled, prove exceedingly deleterious. It combines with a number of salifiable bases. The salts, which are thus formed, will be called hydrofluates. Its properties.

V. Hydrofluoric acid, when perfectly freed from water, is very little heavier than this liquid; but, when diluted to a certain extent, it suffers a condensation, and becomes one-fourth heavier than water. Its freezing point is not known. When exposed to a cold of — 4°, it does not congeal. Its boiling point is not exactly ascertained; it is, however, known to be very low. Spec. grav. 1·06.

VI. Thenard has lately succeeded in combining this acid with oxygen. The method of effecting it, is to add oxyhydrochloric acid to hydrofluate (fluate) of silver. The products are chloride of silver, water, and oxyhydrofluoric acid. It may be oxidized.

VII. When hydrofluoric acid is dropped into water, the action is so violent, as to produce a noise, similar to that occasioned by plunging red-hot iron into the same liquid. On the other hand, when water is dropped into the acid, the former enters immediately into ebullition. The acid, even though very largely diluted, still retains its fuming property. Action of water;

VIII. When hydrofluoric acid is brought in contact with potassium, a violent action takes place; a white solid is formed, and a quantity of hydrogen gas, evolved. This result is explained by supposing that the peculiar radical of hydrofluoric acid, which it is proposed to call fluorine, is combined with hydrogen in the formation of the acid itself; this radical is considered to combine with the potassium, while the hydrogen is evolved. and of potassium.

IX. When silica, which has been precipitated from an This acid

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combines with silica.

alkaline solution, is dried, and mixed, in a state of powder, with pure hydrofluoric acid, a gaseous substance is instantly formed, which possesses the properties of an acid. This gaseous acid is generally considered to be a compound of silica and hydrofluoric acid. It will be described hereafter.

Its probable composition.

X. It has already been mentioned, that chemists have obtained the strongest evidences, that hydrofluoric acid is a compound of a peculiar radical and hydrogen.* This radical (fluorine) has not, indeed, been obtained in a separate state; but forming peculiar compounds with bodies already known. Hence, it must be different from every other form of matter, with which chemists are acquainted.

SECTION II.

OF HYDROCYANIC ACID.

Usual chemical name, *Prussic Acid.*

Scheele's process for obtaining hydrocyanic acid.

I. Scheele's process for obtaining hydrocyanic acid is the following: Boil a mixture of ten parts of Prussian blue in powder, five parts of peroxide of mercury, and thirty parts of water, in a glass vessel, for some minutes. Filter the liquid obtained; and throw upon the matter, remaining on the filter, ten parts of hot water, to wash it completely. Pour the filtered liquid upon two and a half parts of clean iron filings, add at the same time one part of concentrated sulphuric acid, and mix the whole by agitation. Distil the mixture, as it now stands, at a gentle heat, until one-fourth of it has passed over into the receiver. The distilled product will be hydrocyanic acid. It is, however, rendered impure, generally, by admixture of a small portion of sulphuric acid. By a re-distillation, off a portion of carbonate of lime, the sulphuric acid present will be retained, and the acid procured in a state of purity.

* This is the proper place to inform the reader, why the name of the acid of fluor spar has been altered from *fluoric* to *hydrofluoric*. The probable composition of the acid suggested the propriety of the prefix *hydro*. But this circumstance alone would not have been deemed sufficient to justify the alteration. What principally influenced me, were the suggestions of analogy. Both chlorine and iodine form acids by combining with oxygen or hydrogen indifferently; now is it not probable that the radical of the fluor spar acid may form an acid by combining with oxygen? If such an acid compound should be discovered, it could not be called fluoric acid, unless the name of the acid, commonly so called, were changed to hydrofluoric. So that it appears, that if the discovery, anticipated, should really be made, then the alteration, here proposed, would become absolutely necessary. On the other hand, should it not be made, the new name will still be useful, by suggesting the probable composition of the acid.

II. The explanation of Scheele's process, if given in conformity with the light of recent discoveries, may be thus stated. Prussian blue is a compound of peroxide of iron, and a peculiar acid, composed of the elements of hydrocyanic acid united to iron, called ferrocyanic acid. When this substance, in powder, is boiled with peroxide of mercury and water, it becomes decomposed; and its acid combines with the peroxide, in such a manner, as to form cyanodide (commonly called prussiate) of mercury and peroxide of iron. The cyanodide of mercury being soluble, when the whole is placed upon a filter, it passes through; while the peroxide of iron, derived from the decomposition of the Prussian blue, as well as that formed in the manner just mentioned, is retained. When the solution of the cyanodide, in the next step of the process, is poured upon clean iron filings, and sulphuric acid added, the whole being shaken together; water becomes immediately decomposed, its hydrogen combines with the cyanogen of the cyanodide, forming hydrocyanic acid, the mercury being revived; while its oxygen oxidizes the iron. The oxide of iron, thus formed, is then dissolved by the sulphuric acid; so that the resulting substances are mercury, and a liquid containing hydrocyanic acid and sulphate of iron in solution. Now hydrocyanic acid is volatile, which is not the case with sulphate of iron. Accordingly, when the liquid, containing them, is distilled; the acid is driven over into the receiver; while the sulphate is left behind. CHAP. II. Scheele's process explained.

III. Gay-Lussac's method for obtaining hydrocyanic acid is the following: Put a mixture of cyanodide (prussiate) of mercury* and hydrochloric (muriatic) acid in a tubulated retort. Lute to its beak, a glass tube, about two feet long, and $\frac{4}{10}$ths of an inch in diameter. Fill the first third of this tube with pieces of marble, and the remainder with dry chloride of calcium (muriate of lime). To the end of the tube, adapt a small receiver, and surround it with ice. Apply a moderate heat to the retort. A gas is extricated, which condenses on the marble, but may easily be driven forward, by a gentle heat, into the receiver, where it ultimately condenses into a liquid. This liquid is hydrocyanic acid. Gay-Lussac's process.

IV. In the process just given, a mutual decomposition of the hydrochloric acid and the cyanodide of mercury takes place; the chlorine of the acid combines with the Gay-Lussac's process explained.

* Cyanodide of mercury may be formed by boiling a mixture of peroxide of mercury and prussian blue in water, and evaporating liquid until it form crystals.

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mercury of the cyanodide, so as to form perchloride of mercury; while the hydrogen of the former combines with the cyanogen of the latter, and flies off in the form of hydrocyanic acid vapour. When the acid vapour arrives at the receiver, it condenses into a liquid, by the cold produced by the ice. The marble in the tube is intended to retain any hydrochloric acid, which may be driven over along with the hydrocyanic acid. The dry chloride of calcium is for the purpose of absorbing any water which may exist in the acid vapour.

V. Vauquelin has recently published a very interesting memoir on cyanogen and hydrocyanic acid. This chemist repeated the process of Gay-Lussac, just given, for obtaining the acid, but procured but small quantities at a time. The residuum of his process was sometimes perchloride of mercury (corrosive sublimate), the same as in Gay-Lussac's process; at other times, it was a compound of perchloride of mercury and hydrochlorate of ammonia, forming the substance, called by the earlier chemists sal alembroth. Vauquelin thinks the sal alembroth was formed, in consequence of the decomposition of the cyanogen of the cyanodide, which resulted in the formation of ammonia; he having left the cyanodide and hydrochloric acid, in a state of mixture, over night.

Vauquelin's process.

VI. Vauquelin prefers the following process for obtaining hydrocyanic acid: Pass hydrosulphuric acid gas (sulphuretted hydrogen), disengaged from sulphuret of iron by the action of diluted sulphuric acid, over cyanodide (prussiate) of mercury, contained in a tube, gently heated, and communicating with a receiver refrigerated by a mixture of ice and salt. As soon as the hydrosulphuric acid gas comes in contact with the cyanodide of mercury, a double decomposition takes place; the sulphur of the acid combines with the mercury of the cyanodide, forming sulphuret of mercury, which remains in the tube; while the hydrogen of the former, and the cyanogen of the latter, unite in the form of hydrocyanic acid vapour, which passes on and condenses in the refrigerated receiver. A tube, communicating with the receiver, will be found useful; for if the hydrosulphuric acid be disengaged in too great abundance, its odour will be perceived at its orifice, which occurrence is the signal for stopping any further extrication of the acid gas. Any contamination, however, of the hydrocyanic acid by hydrosulphuric acid, may be completely prevented by placing a small portion of carbonate of lead in the extremity of the tube, through which the former is to pass, by which the latter will be arrested. By the process, just detailed, Vau-

quelin obtained a liquid, having all the properties of dry hydrocyanic acid. This method for procuring the acid is easy to perform, and yields a much larger product, than the one by the action of hydrochloric acid.

VII. Vauquelin calls the attention of apothecaries, who wish to prepare hydrocyanic acid to be employed as a medicine, to the following method, invented by Proust. Pass a current of hydrosulphuric acid gas through a cold saturated solution of cyanodide (prussiate) of mercury, until the acid should be in excess. Put the liquid obtained in a flask, closed from the air, agitate it from time to time, and then filter it. If, after filtration, the liquid should still continue to contain traces of hydrosulphuric acid, the presence of which may be ascertained by the smell; it must be mixed with carbonate of lead, and filtered again. The filtered liquid will be a solution of hydrocyanic acid. The manner, in which it becomes formed, is sufficiently obvious. A mutual decomposition takes place between the cyanodide of mercury and the hydrosulphuric acid; which results in the formation of a sulphuret of mercury, and the acid under consideration. By filtering, the sulphuret is removed, and the acid obtained in a state of solution. By pursuing this method for the preparation of the acid, it will be obtained, much more concentrated, than is proper for employment as a remedy; and it will have this advantage over the dry acid, that it keeps, without alteration, for a longer time, if precautions be taken for preventing the influence of heat, or of the atmosphere.*

Proust's process.

This process the best for preparing hydrocyanic acid, to be employed as a remedy.

VIII. Hydrocyanic acid was discovered in consequence of the successive researches, made by chemists, into the nature of Prussian blue. This pigment was accidentally discovered, in 1760, by Diesbach, a preparer of colours, at Berlin. This artist was desirous of precipitating a particular colour; and, for that purpose, borrowed some potash from Deppel, the chemist, who is known as the discoverer of an animal oil, formerly much used in medicine. The potash, instead of producing the colour desired, threw down a beautiful blue powder. Upon investigating the cause of the unexpected production of this blue powder, it was ascertained that the potash employed had been calcined with blood, in some of Deppel's processes. Guided by this information, Diesbach afterwards succeeded in contriving a process, by which he could produce the blue powder at pleasure. This blue powder is Prussian blue.

Hydrocyanic acid, discovered, during the analysis of Prussian blue.

* Vauquelin's paper on cyanogen and hydrocyanic acid may be found in the Annales de Chimie, Vol. IX. (Oct. 1818). All the facts given in the three last paragraphs are taken from his paper.

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Prussian blue; how obtained.

Prussian blue may be prepared by igniting, at a moderate heat, three parts of dried blood, and two parts of carbonate of potash (common potash). The mass is then dissolved in water, and the solution formed, precipitated by a solution of one part of sulphate of iron (green vitriol) and two parts of sulphate of alumina-and-potash (alum). The precipitate which is obtained is green; but, after being washed with diluted hydrochloric (muriatic) acid, it becomes of a beautiful blue colour.

Its chemical nature investigated by Macquer; and

As Prussian blue constituted a very important pigment; it became a desideratum with chemists, to ascertain its exact composition. Macquer was the first chemist of note, who entered upon this investigation. He ascertained several facts, correctly, of it; but drew the erroneous conclusion, that it was composed of iron, supersaturated with phlogiston, or the hypothetical substance, whose presence was supposed to give combustibility to combustible substances.

by Scheele, who separated its colouring matter; which got the name of prussic acid.

Scheele was the next chemist of eminence, who took up the subject. He discovered a method, by which the colouring matter of the pigment, might be separated; and came to the conclusion, that it was a compound of ammonia and charcoal. His process has already been given, in the beginning of the present section. The colouring matter was soon after named prussic acid by Morveau; and it continued to be called by that name, until very lately.

Berthollet repeated and extended the experiments of Scheele. This chemist came to the conclusion, that prussic acid does not contain ammonia ready formed, but is a triple compound of carbon, hydrogen, and azote. This conclusion was confirmed by Clouet, who found that prussic acid was formed, when ammonia is made to pass through a red-hot porcelain tube, filled with charcoal. Now, the ammonia must have been necessarily decomposed, under such circumstances.

Although the researches of Scheele and Berthollet had made manifest the constituents of prussic acid; yet no chemist was aware of the manner, in which they were combined. This discovery was reserved for Gay-Lussac.

Manner in which the constituents of the colouring matter are united, ascertained by Gay-Lussac;

This chemist discovered, in 1815, that a peculiar gaseous fluid might be obtained, by exposing the substance, usually called prussiate of mercury, to a heat, somewhat under redness. He ascertained that it possessed many curious properties, and that it was a compound of carbon and azote. It is the cyanogen* gas, already noticed under the head of

* Cyanogen is derived from κυανος, a blue colour, and γιγνομαι to generate; it being the characteristic constituent in Prussian blue.

carbon. He discovered also, that this gas, combined with hydrogen, constitutes pure prussic acid; and, consequently, that the azote, in this acid, is not combined with hydrogen, in the form of ammonia, but with carbon, forming cyanogen. This discovery, of the manner in which the constituents of the acid are combined, induced Gay-Lussac to alter its name from prussic to hydrocyanic.

and its name changed from prussic to hydrocyanic acid.

IX. Hydrocyanic acid, as obtained by Gay-Lussac's process, is a colourless liquid, possessing a strong smell, similar to that of peach blossoms; and a sharp taste, which, at first, appears cooling, but afterwards produces a burning sensation in the mouth. At the temperature of $44\frac{1}{2}^{\circ}$, its specific gravity is 0·70. At the temperature of $64\frac{1}{2}^{\circ}$, it is 0·69. Its specific gravity, in a state of vapour, compared with common air, is 0·94. Its boiling point is at 79·7°, and its point of congelation, about 5°.

Properties of hydrocyanic acid.

X. Hydrocyanic acid vapour is inflammable. When fired by the electric spark with oxygen, the products are water, carbonic acid, and azote. Iodine exerts no action upon it: this supporter may be volatilized in the acid vapour, without undergoing any change. It is decomposed by chlorine, chlorocyanic acid being formed, and hydrogen, evolved.

XI. When potassium or sodium is heated in hydrocyanic acid vapour, the latter becomes decomposed; cyanodide of potassium or sodium is formed, and hydrogen, evolved. In like manner, cyanodides are formed, when potash, soda, or barytes is heated in this acid gas. When passed over red-hot iron or platinum, the acid vapour is completely decomposed into its ultimate constituents.

XII. Hydrocyanic acid cannot be kept, for any length of time, without undergoing a total change. The products of its decomposition are ammonia, and a charry matter, which is deposited. It does not appear capable of combining with salifiable bases. When the attempt is made to produce this combination, a double decomposition takes place, and a cyanodide and water are formed. Some of these decompositions will be detailed under the heads of the salifiable bases.

It decomposes, spontaneously, into ammonia and charcoal.

XIII. Hydrocyanic acid is composed of

Its composition.

$$\left.\begin{array}{l}\text{Azote 14—one atom.}\\ \text{Carbon 12—two atoms.}\end{array}\right\} = \text{Cyanogen 26—one atom.}$$

Hydrogen 1—one atom.

Giving 27 for the number representing the weight of its atom.

XIV. Hydrocyanic acid is a very deleterious, narcotic poison. It has been employed of late, by Magendie, as a

Its properties, as a remedy;

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remedy in pulmonary consumption. It does not appear capable of arresting the progress of this dreadful disease, when completely formed; but in some cases, yet in the incipient state, it has calmed the irritation, which gives rise to cough, and lessened expectoration in a remarkable degree. This acid, as a remedy in phthisis, has deservedly attracted the attention of practitioners in different countries; and is now undergoing such trials, as will, no doubt, determine, with precision, its medicinal powers.

CLASS IV.

ACIDS OF IRREGULAR CONSTITUTION.

Acids of irregular constitution, enumerated.

This class of acids embraces the following compounds:

1. Chlorocarbonic Acid.
2. Chloriodic Acid.
3. Borofluoric Acid.
4. Silicofluoric Acid.
5. Chlorocyanic Acid.
6. Sulphocyanic Acid.
7. Ferrocyanic Acid.

These acids will be described in the seven following sections.

SECTION I.

OF CHLOROCARBONIC ACID,

Phosgene gas of J. Davy.

Chlorocarbonic acid; how obtained.

I. Chlorocarbonic acid may be obtained by the following process: Into a flask, made as dry as possible and exhausted of air, introduce equal volumes of chlorine gas and carbonic oxide gas, previously dried, as completely as possible, by being left in contact with fused chloride of calcium (muriate of lime). Expose the mixture to sunshine for about a quarter of an hour. The gases diminish to one-half their original bulk, the chlorine, at the same time, losing its peculiar colour. The resulting gas is chlorocarbonic acid. It was discovered, in 1812, by Dr. John Davy.

Its properties.

II. Chlorocarbonic acid is a gaseous fluid, invisible and elastic like common air. Its smell is very strong, and has been compared to that which would be produced by the mixture of the odours of chlorine and ammonia. Its fumes are more strong and suffocating than those of chlorine: their action on the eyes causes a painful sensation, and a rapid flow of tears. It changes vegetable blues to red, and

has other properties of an acid. It is decomposed by water, and is converted into hydrochloric (muriatic) acid and carbonic acid. Its decomposition is produced also, when antimony, arsenic, zinc, or tin, is heated in it; the chlorine being absorbed by these metals, and carbonic oxide, left behind. It is not known to combine with any salifiable base but ammonia. Chap. II.

III. Chlorocarbonic acid is composed of Its composition.

$$\left.\begin{array}{l}\text{Oxygen } 8\text{—one atom.}\\ \text{Carbon } 6\text{—one atom.}\end{array}\right\} = \text{Carbonic oxide } 14\text{—one atom.}$$

Chlorine 36—one atom.

Giving 50 for the number representing the weight of its atom.

SECTION II.

OF CHLORIODIC ACID.

Chloruret of Iodine of Gay-Lussac.

I. Chloriodic acid is formed, when a current of chlorine is made to pass into a vessel containing iodine. A combination takes place, and the compound formed is chloriodic acid. Chloriodic acid; how obtained.

II. This acid was first discovered by Sir H. Davy; and afterwards by Gay-Lussac, without being aware of the previous discovery of Davy.

III. Chloriodic acid is a solid substance; and, when neither of its constituents is in excess, it has a yellow colour. When, however, the iodine is in excess, it is red. It is very volatile, and deliquesces, when exposed to the open air. Its properties.

IV. Chloriodic acid dissolves in water. This solution is colourless, if neither constituent of the acid be in excess; but if the chlorine predominates, it has a yellow colour. It gradually destroys vegetable colours, and possesses many of the properties of an acid. It is always decomposed, whenever the attempt is made to unite it with a salifiable base; water being decomposed, and hydrochloric (muriatic) and iodic acids, being formed. No analysis, which can be depended upon for accuracy, has been made of this acid. Dissolves in water.

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SECTION III.

OF BOROFLUORIC ACID.

Usual chemical name, *Fluoboric Acid.*

Borofluoric acid; how obtained. I. Borofluoric acid may be obtained by applying the heat of a lamp to a mixture, in a retort, of one part of finely pulverized fused boracic acid, two parts of fluor spar (hydrofluate of lime) and twelve parts of sulphuric acid. A gas is disengaged, which must be collected over mercury: this gas is borofluoric acid. It was discovered, in 1808, by Gay-Lussac and Thenard.

Its properties. II. Borofluoric acid is a gaseous fluid, invisible and elastic like common air. Its taste is exceedingly acid, and its smell resembles that of hydrochloric (muriatic) acid. It instantly changes vegetable blues to red. It may be passed over red-hot iron, without undergoing decomposition. It is about two and one-third times as heavy as common air. It combines with salifiable bases, and forms salts which will be called borofluates.

Spec. grav. 2·37.

Absorbed, in large amount, by water. III. Water absorbs 700 times its volume of borofluoric acid gas, and becomes nearly four-fifths heavier. Liquid borofluoric acid, which is thus formed, has a certain degree of viscidity; in which circumstance, as well as in requiring a high temperature for ebullition, it resembles liquid sulphuric acid. When heated, it emits fumes, until about one-fifth of the acid gas has separated; after which, the further increase of heat produces no effect. It agrees also with liquid sulphuric acid, in the manner in which it acts upon animal and vegetable substances; it converting them into charcoal.

IV. When potassium or sodium is heated in borofluoric acid gas; these metals undergo combustion, and the acid is decomposed. Fluoride of potassium or of sodium is formed, intermixed with boron. When either of these fluorides is thrown into water, this liquid is decomposed, and hydrofluate (fluate) of potash or soda is formed. Hence, it is evident that borofluoric acid is a compound of boron and fluorine; but united in what proportional quantities is not known.

SECTION IV.

OF SILICOFLUORIC ACID.

Usual chemical names, *Silicated Fluoric Acid.—Fluosilicic Acid.* The *Fluoric Acid* of Scheele.

Silicofluoric acid; how obtained.

I. SILICOFLUORIC ACID may be obtained by exposing equal parts of pulverized fluor spar and glass, made into a paste with sulphuric acid, to a gentle heat, in a retort. A gas is extricated in abundance, which must be collected over mercury. This gas is silicofluoric acid.

Account of the researches, which led to the discovery of its true nature.

II. As the history of this acid gas is very much connected with the researches, which have been made by chemists, from time to time, into the nature of fluor spar, frequently called Derbyshire spar, it is proper to give a short account of them.

Fluor spar was formerly used as a flux to facilitate the fusion of ores; and it is from this circumstance that it has its name. Nothing had been ascertained of its chemical nature, except that it had the power, under certain circumstances, of corroding glass, a fact which was known, at Nuremberg, as early as the year 1670, until Margraff published a dissertation on it, in the Berlin Transactions for 1768. This chemist ascertained, that sulphuric acid was not one of its ingredients, as had been previously conjectured; and procured, by the action of this acid upon it, a white sublimate, which he supposed to be the fluor spar itself, undecomposed. He observed, also, that the retort, in which the experiment had been made, was corroded into holes in several places.

In 1771, three years after the publication of Margraff; Scheele published a set of experiments upon fluor spar. This chemist resolved it into lime, and a peculiar acid, before that time unknown, to which he gave the name of fluoric acid, from the name of the spar itself. He examined the acid, which he obtained, and noted many of its properties. The subject was soon after pursued by Priestley. This chemist demonstrated that the acid, obtained by Scheele, was a gaseous fluid, and added considerably to the knowledge previously possessed with regard to its nature.

Although the fluoric acid of Scheele remained an undecompounded substance, contrary to the analogy of the other acids; yet it was considered to be perfectly well ascertained, that it was the acid existing in fluor spar. This opinion was universally held, when Weigleb, Bucholz, and

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Meyer successively proved, that the fluoric acid of Scheele contained silica, which did not exist, necessarily, in the acid of fluor spar; but entered into combination with it, in consequence of its extrication in glass vessels; such vessels being always, in part, dissolved by its action.

In 1808, Gay-Lussac and Thenard discovered, that, by distilling fluor spar containing no silica, with concentrated sulphuric acid, in leaden vessels, an acid is obtained, very different from the fluoric acid of Scheele, in which silica is not a constituent.

In 1812, Dr. John Davy ascertained, that the fluoric acid of Scheele contained silica, not as an accidental, but as an essential constituent; and that the acid of Scheele was composed of the fluoric acid of Gay-Lussac and Thenard, and silica, united in an invariable proportion. Hence, therefore, Scheele did not discover the acid of fluor spar; but the acid, which he obtained, is a peculiar one, composed of the true acid of this spar and silica. It is this peculiar acid, which furnishes the subject of the present section. The true acid of fluor spar, commonly called fluoric acid, has already been described, under the name of hydrofluoric acid.

Properties of silicofluoric acid.

III. Silicofluoric acid is a gaseous fluid, invisible and elastic like common air. It possesses a very sour taste, and a smell, similar to that of hydrochloric (muriatic) acid. It changes vegetable blues to red. When allowed to escape into the open air, it assumes the form of white fumes, owing to its combination with moisture. It is about three and a half times as heavy as common air. It is absorbed by water, which takes up 263 times its volume of the acid gas; but it is decomposed, and deposites its silica.

Spec. grav. 3·57.

Its probable composition.

IV. As to the composition of silicofluoric acid, the most usual opinion is, that it is a compound of hydrofluoric (fluoric) acid and silica. If this should turn out to be its true composition; then, according to the nomenclature adopted in this work, it should be called silicated hydrofluoric acid. Sir H. Davy, however, supposes, from analogy, that it is composed of fluorine and silicum.*

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* The reader has, no doubt, noticed, that I have taken the liberty of proposing new names for the acids last described. I purposely omitted any explanation on the subject, until both acids were described; in order that one notice of the alterations might serve for both.

As I had rejected the opinion that silica is an acid, or silicum acidifiable, I could not give, to the names of these substances, the characteristic termination of an acid. Hence, it could not be proper to call the acid, here denominated silicofluoric acid, by the name of fluosilicic acid, or the salts formed by it, fluosilicates. These latter salts have, therefore, been called silicofluates, which is a better term, as it has some conformity with their old name, fluates. The discoverers of borofluoric acid (Gay-Lussac & Thenard) have given to it, the name of fluoboric

SECTION V.

OF CHLOROCYANIC ACID.

Oxyprussic Acid of Berthollet.

I. Chlorocyanic acid may be obtained by the following process: Pass a current of chlorine through a solution of hydrocyanic acid, in water, until the latter discolours indigo dissolved in sulphuric acid. Agitate the liquid obtained with mercury, in order to remove any excess of chlorine. The liquid is now a solution of chlorocyanic acid. To separate it in a pure state, a glass cylinder is filled, two-thirds with mercury, and the remainder with this liquid, and then inverted in a basin of mercury. The cylinder, thus disposed, is put under the receiver of an air-pump, and the air exhausted, until the whole of the mercury and liquid, contained in the cylinder, sinks into the basin; the space in the cylinder, being filled with chlorocyanic acid vapour. Upon letting the air into the receiver again; the mercury rises in the cylinder, and the chlorocyanic vapour becomes condensed into a liquid, and is thus obtained pure. Chlorocyanic acid; how obtained.

II. Berthollet was the first chemist who formed this acid; but he was led to believe, that it was a compound of oxygen and prussic (hydrocyanic) acid. Its real nature was ascertained, in 1815, by Gay-Lussac, who obtained it, in a separate state, by the process just given. Discovery.

III. Chlorocyanic acid is a colourless liquid, possessing a peculiar odour. Its vapour, when drawn into the nose, stimulates the Sneiderian membrane, and occasions a flow of tears. It is capable of combining with water. It is not known to combine with any of the salifiable bases. Its properties.

IV. Chlorocyanic acid is composed of

$$\left.\begin{array}{l}\text{Azote } 14\text{—one atom.}\\ \text{Carbon } 12\text{—two atoms.}\end{array}\right\} = \text{Cyanogen } 26\text{—one atom.}$$

$$\text{Chlorine } \underline{36}\text{—one atom.}$$

Giving 62 for the number representing the weight of its atom.

(fluoborique) acid. Both the constituents of this acid are acidifiable; and, perhaps, it may be called by both these names with equal propriety But in order that the acids, containing fluorine (or hydrofluoric acid) might have a uniform termination, formed from the name of this substance, the name of borofluoric acid has been substituted for fluoboric acid.

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SECTION VI.

OF SULPHOCYANIC ACID.

Sulphuretted Chyazic Acid of Porrett.—*Anthrazothionic Acid* of Grotthuss.

Sulphocyanic acid; how obtained.

I. Sulphocyanic acid may be obtained by the following process: Dissolve one part of sulphuret of potash in water, and boil it with three or four parts of Prussian blue in powder, added at intervals: sulphuret of iron becomes formed; and there remains in solution, sulphocyanic acid, combined with potash, together with sulphate and hyposulphite of potash. At this stage of the process, add sulphuric acid to the liquid, until it become decidedly acid. Then heat it nearly to the boiling point, for some time, and add a little peroxide of manganese: the liquid will assume a crimson colour. Now add to it a solution of two parts of persulphate of copper, and three parts of sulphate of iron, until the crimson colour disappear. A copious precipitate falls, which is sulphocyanic acid, in combination with protoxide of copper. By boiling this salt in liquid potash, the acid becomes dissolved, and the protoxide is left behind. Mix the solution of the acid in liquid potash, thus obtained, with sulphuric acid, and distil in a retort. The product of the distillation will be sulphocyanic acid.

Its chemical nature, doubtful.

II. Sulphocyanic acid was discovered, in 1808, by Porrett, by whom it was called prussous acid. This chemist re-examined this acid in 1814, and ascertained that it contained sulphur; and finally concluded, that it is a compound of hydrocyanic acid and sulphur. A chemist, of the name of Grotthuss, has still more lately examined this acid; and concludes, that it contains neither cyanogen nor hydrocyanic acid, ready formed; but the constituents of these compounds. He thinks that azote and hydrogen are present in it, in the requisite proportions to form ammonia; but he does not believe that the acid contains this alkaline base ready formed. The theory of the composition of the acid, which this chemist embraces, is, that it has a triple compound base, consisting of carbon, azote, and sulphur, which he proposes to call anthrazothion,* and that this base is acidified by hydrogen. The acid itself he calls anthrazothionic acid. Vogel combats the conclusions of Grotthuss, shows in what way his experiments were fallacious, and coincides in opinion

* From the Greek words signifying charcoal, azote, and sulphur.

with Porrett, that this acid is really a compound of hydrocyanic acid (or its elements) with sulphur.* Chap. II.

III. Sulphocyanic acid is a colourless liquid, possessing a strong smell, which somewhat resembles that of acetic acid (distilled vinegar). In a state of the greatest concentration, it is very little heavier than water. When subjected to distillation, it is partially decomposed. Its combinations with salifiable bases are called, by Dr. Thomson, sulphocyanates. Its properties. Spec. grav. 1·022.

IV. According to Porrett, sulphocyanic acid is composed, in whole numbers, of

Hydrocyanic acid	27—one atom.
Sulphur	51—more than three atoms.

So that it appears, that the proportion, in which the proximate constituents of this acid combine, does not accord with the atomic theory.

V. Vogel has ascertained that sulphocyanic acid possesses the properties of a very active poison. When concentrated, even in a small dose, it produces death very quickly. When diluted and given in repeated doses, it exhibits its effects more particularly upon the organs of respiration, and extinguishes life more slowly.† An active poison.

SECTION VII.

OF FERROCYANIC ACID.

Ferruretted Chyazic Acid of Porrett.

I. Ferrocyanic acid may be obtained by the following process: Dissolve the salt, usually called triple prussiate of barytes, which is a compound of ferrocyanic acid and barytes, in cold water, and add absolute sulphuric acid, in the proportion 2·53 grains for every 10 grains of the salt employed. The sulphuric acid will combine with the barytes of the triple prussiate, and gradually fall in the form of an insoluble sulphate. After removing the sulphate by the filter, the remaining liquid will be a solution of ferrocyanic acid. Ferrocyanic acid; how obtained.

II. Porrett has lately given a method for obtaining ferrocyanic acid in the state of crystals. The process consists in adding an alcoholic solution of crystallized tartaric acid to the triple prussiate (ferrocyanate) of potash. All the potash,

* Annals of Philosophy (Feb. 1819.) † Ibid. p. 106.

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present in the salt, will fall in combination with the tartaric acid, in the form of bitartrate of potash (cream of tartar), while the ferrocyanic acid will be found dissolved in the alcohol. By spontaneous evaporation, the acid falls in the form of crystals.*

Its discovery connected with the investigations of the triple prussiates.

III. As the history of this remarkable acid is connected very closely with the investigations, made by chemists, into the nature of the salts, usually called triple prussiates, it will be proper to give some account of these peculiar combinations.

A very short and imperfect account has already been given of hydrocyanic acid, or, as it is usually called, prussic acid. It was very soon remarked by chemists, that this acid forms salts in a very imperfect manner, unless iron be present in them; and subsequent investigations have even made it doubtful whether it be capable of combining with salifiable bases at all. Prussiates, which were made permanent by the presence of iron, were supposed to be salts containing two bases, of which protoxide of iron was considered to be one. For example, the compound called prussiate of potash, when made permanent by the presence of iron, was called prussiate of potash-and-iron, or more usually triple prussiate of potash. The only permanent simple prussiate, formerly supposed to be known, was the prussiate of iron; and, in this salt, the iron appeared to exist in two states of combination with oxygen, both as a protoxide and a peroxide.

Anomalies of the triple prussiates, stated.

The facts just stated were viewed with surprise by chemists. No salts but the prussiates exhibited similar chemical relations. Other acids were capable of combining with a variety of double bases; but the prussic acid could form no triple salt, which had not iron for its second base. Neither did it appear capable of forming any permanent simple salt, except with iron. It was further observed, that the properties of the triple prussiates are not only different, but diametrically opposite to those of the compounds called simple prussiates. The triple prussiates are permanent in the atmosphere, and are not easily decomposed by any acid, however powerful: whereas the compounds called simple prussiates suffer spontaneous decomposition in the air, and their acid is displaced by every other acid. The triple prussiates are particularly remarkable in not yielding indications of the presence of iron, when treated with the reagents for the detection of this metal. From all these facts

* Annals of Philosophy, p. 217. (Sep. 1818).

it was evident, that iron possessed chemical relations to the prussiates, which could not be satisfactorily explained on the supposition, that it was present in these salts as a salifiable base. CHAP. II.

They are explained by the discovery of the ferrocyanic acid by Porrett.

The difficulties, which were presented by the triple prussiates, were at last removed by Porrett. This chemist has satisfactorily shown, that iron exists in these compounds, not as a salifiable base, but as a constituent of an acid, which is peculiar to them alone. Hence, therefore, the compounds called triple prussiates are not triple salts, but, in reality, simple salts, composed of Porrett's ferruretted acid, united to different bases; and, being a distinct set of salts from the prussiates (so called), their permanency, when compared with the latter, can no longer be a matter of surprise. By the aid of Porrett's discovery, the nature of the compound, usually called prussiate of iron, is satisfactorily explained. It is not a prussiate, but a salt composed of the ferruretted acid and peroxide of iron; and, hence, its permanency is accounted for. It contains iron in two states of combination, because this metal is present in it, both as a constituent of its acid and of its base.

The reader has now had explained to him, in a very concise way, the nature of Porrett's discovery, which terminated in demonstrating the true nature of the peculiar compounds erroneously called triple prussiates. It is Porrett's ferruretted acid, under the name of ferrocyanic acid, which furnishes the subject of the present section.

Properties of ferrocyanic acid.

IV. Ferrocyanic acid, in a state of solution, is a liquid of a pale yellow colour. It is destitute of smell. It suffers decomposition, when exposed to a gentle heat or to a strong light. It expels all acids from salts, with whose bases it may form insoluble compounds. Its compounds with salifiable bases will be called ferrocyanates. These combinations are usually called triple prussiates.

Its precise composition, not correctly known.

V. The precise composition of the ferruretted acid still remains in great doubt. Porrett appears at first to have considered it to be a compound of protoxide of iron and hydrocyanic (prussic) acid. Dr. Thomson, however, from theoretical grounds, considered it, in his system of chemistry, a compound of iron and cyanogen, and called it ferrocyanic acid. This latter chemist has recently published a paper upon the triple prussiate of potash,* in the course of which he examines Porrett's acid, and concludes that it is a compound of hydrocyanic acid and iron; he, however, was not enabled to reconcile this composition with the atomic

* Annals of Philosophy XII. 102.

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theory. In consequence of the investigations of Thomson; Porrett was led to re-examine the same triple prussiate; and the results which he obtained, induced him to believe that the ferruretted acid contains metallic iron, as Dr. Thomson first supposed, combined with the elements of two atoms of hydrocyanic acid—an atom of azote. Or to state the composition fully, he considers the ferruretted acid to be composed of

Carbon	24—four atoms.
Azote	14—one atom.
Hydrogen	2—two atoms.
Iron	28—one atom.
	68

The composition, which Porrett assigns to the ferruretted acid gives an equivalent number for it, which acccords very well with that deduced from the ferrocyanates of barytes and potash.*

Although it is doubtful in what way the constituents of this acid are united; yet it appears to be perfectly well ascertained that hydrogen is one of its ingredients. Of course Dr. Thomson's name, ferrocyanic acid, is not correctly formed. Notwithstanding, this appellation is retained, in preference to Porrett's name, which has the disadvantage of being long and harsh-sounding.

As the ferrocyanic acid, as well as the acid last described, contains hydrogen, perhaps these compounds should have been classed as acids, whose bases form acid compounds with hydrogen only. But as their chemical nature is but imperfectly understood, and as yet a subject of controversy, it appeared most expedient to place them amongst the acids of irregular constitution.

CLASS V.

ACIDS IN WHICH OXYGEN AND HYDROGEN ARE BOTH PRESENT.

Fifth class of acids enumerated.

Acids belonging to this class are the following:

1. Uric Acid.	9. Tartaric Acid.	17. Pyrotartaric Acid.
2. Purpuric Acid.	10. Benzoic Acid.	18 Moroxylic Acid.
3. Gallic Acid.	11. Saclactic Acid.	19. Suberic Acid.
4. Formic Acid.	12. Citric Acid.	20. Laccic Acid.
5. Oxalic Acid.	13. Mellitic Acid.	21. Kinic Acid.
6. Sorbic Acid.	14. Camphoric Acid.	22. Zumic Acid.
7. Succinic Acid.	15. Malic Acid.	23. Boletic Acid.
8. Acetic Acid.	16. Lactic Acid.	

* Annals of Philosophy XII. 215. (Sept. 1818.)

These acids will be described, in the order in which they have been enumerated, in the following sections. CHAP. II.

SECTION I.

OF URIC ACID.

(Formerly called *Lithic Acid.*)

I. URIC ACID may be obtained by the following process: dissolve calculi, which are composed principally of this acid, in liquid potash, and precipitate the solution by means of hydrochloric (muriatic) acid. The precipitate, after being washed with a little ammonia to separate adhering acid, and afterwards with warm water, is pure uric acid. Uric acid; how obtained.

II. Certain urinary calculi are composed almost entirely of uric acid. They are known by certain external marks, familiar to the chemist. When they are dissolved in liquid potash, a solution of urate of potash becomes formed. When hydrochloric acid is added to this solution, it combines with the potash and remains in solution, while the uric acid is precipitated.

III. Uric acid was discovered in 1776 by Scheele, who described many of its properties. The results of this chemist were afterwards confirmed by Bergman. The French chemists soon after gave it the name of lithic acid. In 1797, Dr. Wollaston published a paper on the calculous concretions, and added much to what was previously known respecting this acid. The following year Dr. Pearson published a paper on the same subject, and enlarged considerably the previous knowledge of its nature. This chemist proposed to alter the name of the acid, from *lithic* to *uric*, a change which is now almost universally adopted. Fourcroy and Vauquelin next examined the acid, in their treatise on urinary calculi. Lastly Dr. Henry, in 1807, published a very full account of the uric acid. Its history.

IV. Uric acid is a white powder, possessing a harsh, but not a gritty feel. It is destitute of taste or smell. It changes infusion of litmus to a red colour. It dissolves in 1720 times its weight of water, at the temperature of 60°; and in 1150 times its weight of boiling water. As the boiling solution cools, the acid falls in the form of minute crystals. When subjected to distillation, there come over into the receiver, 1. a drop or two of water, holding carbonate of ammonia in solution; 2. dry carbonate of ammonia; 3. a substance, which has acid properties, and which has been distinguished by the name of acid sublimate; and there remains in the retort, a coal amounting, in weight, to about one-sixth of the acid employed. Its properties.

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V. Uric acid combines with salifiable bases, and forms salts called urates.

Its composition.

VI. According to an analysis lately made by Dr. Prout, uric acid is composed of

Azote	14—one atom.
Carbon	12—two atoms.
Hydrogen	1—one atom.
Oxygen	8—one atom.
	35

Giving 35 for the number representing its atom.*

SECTION II.

OF PURPURIC ACID.

Purpuric acid; formed by the action of nitric acid upon uric acid.

I. Ever since the discovery of uric acid, it had been observed by chemists, that this acid, when treated with diluted nitric acid, forms a solution of a beautiful pink colour. This solution has lately been examined by Dr. Prout, who has ascertained that it is composed of a peculiar acid principle united to ammonia. For the acid principle, Dr. Wollaston has proposed the name of purpuric acid, which is adopted by Dr. Prout. It is this newly discovered acid, which furnishes the subject of the present section.

How obtained in a separate state.

II. Dr. Prout obtained the purpuric acid in a separate state by the following process: He digested pure uric acid in dilute nitric acid; whereby an effervescence took place, and the uric acid was dissolved. He next neutralized the excess of nitric acid with ammonia, and concentrated the whole by slow evaporation: as the evaporation proceeded, purpurate of ammonia separated in dark-red granular crystals. By treating the purpurate with sulphuric or hydrochloric (muriatic) acid, the ammonia was separated, and the purpuric acid fell in the form of a precipitate.

Its properties.

III. Purpuric acid is in the form of a very fine powder, of a slightly yellowish or cream colour. Its specific gravity is considerably above that of water. It is very sparingly soluble in water, and perfectly insoluble in alcohol or ether. It does not affect the colour of litmus paper, which Dr. Prout supposes to be owing to its sparing solubility. It does not deliquesce in the air, but acquires a purplish tint, which is owing to the spontaneous formation of ammonia.

* Annals of Philosophy XI. 355.

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When exposed to heat, it neither melts nor sublimes, but becomes purple and burns away gradually, without exhaling any remarkable odour. When heated in close vessels, the products are carbonate of ammonia, some hydrocyanic (prussic) acid, a little liquid having an oily appearance, and charcoal. It combines with a number of salifiable bases, with which it forms peculiar salts, proposed to be called purpurates.

Composition.

IV. According to Dr. Prout, purpuric acid is composed of

Azote	14—one atom.
Carbon	12—two atoms.
Hydrogen	2—two atoms.
Oxygen	16—two atoms.
	44

Giving 44 for the number representing its atom.*

Upon comparing purpuric acid with uric acid, it is perceived that they agree as to constituents. The only difference between them consists in the presence of an atom of hydrogen and of oxygen in the former, not to be found in the latter.

The uric and purpuric acids are the only acid compounds of the fifth class which contain azote. All the remaining acids, belonging here, are ternary combinations of carbon, hydrogen and oxygen.

SECTION III.

OF GALLIC† ACID.

Gallic acid; how obtained.

I. Gallic acid may be obtained by exposing pulverized nutgalls, in a large retort, to a heat, cautiously and gradually raised. A substance sublimes in a crystallized form, which is pure gallic acid. This process, however, does not succeed without a great deal of precaution; for if the heat be not withdrawn soon enough, a portion of oil is driven over also, which dissolves the crystals, which may have previously formed. The following method is more easily managed.

* The above facts respecting purpuric acid have been taken from Dr. Prout's paper on an acid principle prepared from uric acid.—Phil. Trans. 1818. part II. p. 420.

† From *galla*, the Latin name for the oak-gall, the vegetable substance from which gallic acid was first obtained.

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This acid was discovered by Bergman and Scheele. A number of substances yield it besides sugar. It may be formed by the action of nitric acid upon gum, alcohol, honey, and a great variety of animal and vegetable substances.

Its properties.

II. Oxalic acid, obtained by the process just given, is in the form of transparent crystals, possessing a fine white colour and considerable lustre. They have an acid taste, and redden all vegetable blues except indigo. When cautiously exposed to heat, in a sand bath, they lose their water of crystallization, and fall to powder. When in the form of crystals, the acid is not altered by exposure to air; but when subjected to a considerable heat, it emits a smoke, which affects disagreeably the nose and eyes, and becomes partially decomposed. When taken into the stomach, in considerable quantities, it acts as an energetic poison. In the amount of an ounce, it proves almost immediately fatal.

III. Crystallized oxalic acid is soluble in twice its weight of water, at the temperature of 65·7°, and in its own weight of boiling water. The solution, when concentrated, has a very acrid taste; but when sufficiently diluted, it becomes agreeably sour. Oxalic acid dissolves in hydrochloric (muriatic) acid without decomposition. It is partly decomposed by sulphuric acid when assisted by heat, and a portion of charcoal formed. It is totally decomposed by nitric acid, being converted into water and carbonic acid.

Products of its decomposition by heat.

IV. The combinations of oxalic acid with salifiable bases are called oxalates. When these salts, in a dry state, are exposed to a red heat, their acid becomes totally decomposed, and its constituents recombine so as to form five new substances; namely, water, carbonic acid, carbonic oxide, bihydroguret of carbon (carburetted hydrogen) and charcoal. Hence its constituents are carbon, hydrogen, and oxygen.

Its composition.

V. According to an analysis, performed by Gay-Lussac and Thenard, calculated in proportional numbers, which best accord with the atomic theory, oxalic acid is composed of

Carbon	12·05—two atoms, very nearly.
Hydrogen	1·20—one atom, nearly.
Oxygen	32·00—four atoms.

Supposing this acid to contain exactly the number of atoms, which appear to be indicated by the above analysis, then the number representing its atom would be 45.

SECTION VI.

OF SORBIC* ACID.

I. Sorbic acid was discovered, in 1815, by Donovan, in the expressed juice of the berries of the mountain ash (pyrus aucuparia). Its peculiar nature has since been amply confirmed by Vauquelin and Braconnot. Sorbic acid; its discovery.

II. The outline of Donovan's process for obtaining this acid is to saturate the expressed juice of the berries with acetate of lead (sugar of lead), whereby a sorbate of lead becomes formed. This sorbate is then partially decomposed by sulphuric acid, and the lead, contained in the resulting supersorbate, is thrown down by means of a current of hydrosulphuric acid (sulphuretted hydrogen). Preparation.

III. Sorbic acid, when first obtained, is a liquid, colourless and inodorous, and possessing an intensely sour taste. When evaporated to the consistence of a syrup, it forms a mass of a crystalline structure, which still contains a considerable quantity of water, and deliquesces in a moist atmosphere. With acetate of lead, it gives a precipitate, white and flocculent at first, but afterwards becoming of a crystalline appearance. By the action of nitric acid, it is converted into oxalic acid; from which circumstance Vauquelin concludes, that it bears considerable analogy to malic acid. This chemist also suggests that sorbic acid, being colourless and inodorous and possessing an agreeable taste, might be employed, in medicine and the arts, as a substitute for tartaric and citric acids. Its properties.

IV. According to an analysis performed by Vauquelin, reduced to numbers, which best accord with the atomic theory, sorbic acid is composed of Composition.

Carbon	11·76—two atoms, nearly.
Hydrogen	7·00—seven atoms.
Oxygen	22·89—three atoms, most nearly.

Supposing this acid to contain exactly two atoms of carbon, and three atoms of oxygen, then the number representing its atom would be 43.†

* From sorbus, the old generic name of the plant from which this acid is obtained.

† The greater part of the facts, contained in this section, are taken from abstracts of the papers of Vauquelin and Braconnot, contained in the Annals of Philosophy, Vol. XII. (Oct. 1818.) p. 290. et seq.

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SECTION VII.

OF SUCCINIC* ACID.

Common name, *Salt of Amber*.

Succinic acid; how obtained.

I. SUCCINIC ACID may be obtained by the following process: Fill a glass retort, half full, with a mixture of amber reduced to powder, and fine sand. The object of the sand is to prevent the amber from running into a mass, when exposed to heat. Distil the mixture, in a sand bath, at a heat gradually increased. A substance sublimes in the neck of the retort. This substance is succinic acid, rendered impure by an oily substance, called oil of amber, which is also a product of the distillation. The acid may be obtained pure by dissolving the sublimate in water, filtering the solution formed, and setting it aside for spontaneous evaporation. Crystals will form in the solution, which consist of succinic acid.

Furnished by amber only.

II. Amber is the only substance, which is known to yield succinic acid. It is a brown, transparent, inflammable body, susceptible of polish, found at some depth in the earth, and on the sea coasts of several countries. It had long been known that a volatile substance could be obtained from it by distillation; but it was Boyle, who first remarked that this substance had acid properties. Its chemical nature, however, was first ascertained experimentally by Pott.

Properties of succinic acid.

III. Succinic acid, when obtained by the process just given, is in the form of transparent, white, shining crystals, possessing an acid taste. It is capable of reddening some vegetable blues. It does not possess corrosive properties. At the heat of a sand bath, it melts and sublimes, but not without suffering a partial decomposition. It is soluble in either sulphuric or nitric acid, without decomposition. Hydrochloric (muriatic) acid, when cold, has very little effect upon it. It dissolves in 96 times its weight of water at the temperature of 50°, and in twice its weight of boiling water. Its combinations with salifiable bases are called succinates.

Its composition.

IV. According to an analysis, performed by Berzelius, given in numbers, which best accord with the atomic theory, succinic acid is composed of

Carbon	24·0—four atoms.
Hydrogen	2·2—two atoms, nearly.
Oxygen	24·0—three atoms.

* Derived from the Latin word *succinum*, amber.

Supposing there existed, in this acid, hydrogen exactly equivalent to two atoms, then the number representing an atom of succinic acid would be 50. CHAP. II.

V. Succinic acid is never used in medicine, but oil of amber is sometimes employed as an antispasmodic.

SECTION VIII.

OF ACETIC* ACID.

(Radical vinegar.)

I. ACETIC ACID may be obtained by distilling acetate of copper (verdigris) at a heat, gradually increased to the point of redness. A liquid is driven over into the receiver, which has a greenish tinge, owing to the presence of copper. By a re-distillation, the copper is separated, and a colourless liquid obtained, which constitutes a very concentrated solution of acetic acid. Acetic acid; how obtained.

II. It may be obtained, in the form of crystals, by distilling a mixture of three parts of acetate of potash, and four parts of sulphuric acid. A liquid is driven over into the receiver, which is a very concentrated solution of acetic acid, mixed with a portion of sulphuric acid. To separate the latter acid, distil the liquid, off acetate of barytes: the sulphuric acid is retained, and the liquid, which comes over, forms crystals of pure acetic acid.

III. Acetic acid constitutes the basis of the well known liquid called vinegar. In vinegar, however, it is largely diluted with water, and mixed with bitartrate of potash (tartar), a portion of alcohol, several vegetable acids, colouring matter and a portion of mucilage. Vinegar is made by exposing wine, beer, or similar liquids to the contact of the atmosphere, at a temperature at least as high as 80°, mixed with some substance to act as a ferment. When vinegar is distilled, it loses many of its impurities, and takes the name of distilled vinegar, or acetous acid. Vinegar, when thus altered, was formerly supposed to contain an acid, differing from the acetic acid, in containing less oxygen; and hence it got the name of acetous acid. But it has been ascertained that there is no other difference, between acetous and acetic acid, than in the quantity of water which they contain; the acetous acid being, in fact, acetic acid, diluted to a certain extent. Properly speaking, therefore, acetous acid It is the acid of vinegar.

* Derived from *acetum*, the Latin word signifying vinegar.

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does not exist. As vinegar is a very important substance, both in the arts and in medicine, it may be proper to notice its manufacture and properties.

Boerhaave's method for making vinegar.

1. Boerhaave gives the following method for making wine vinegar: Prepare two large oaken hogsheads, with a wooden grate, fastened at about one foot from their bottoms. Set the hogsheads upright, and after having placed a moderately close layer of green twigs or cuttings of vine upon the grates, fill them up to the top with the foot stalks of grapes. The wine, to be converted into vinegar, is now poured into the hogsheads, so as to fill one of them to the top, and the other half full. They are left in this state for twenty-four hours; at the end of which time, the half full hogshead is filled to the brim, from the full hogshead. This operation is repeated every twenty-four hours, so as to keep the hogsheads alternately full and half full, for fifteen days in summer, but for a longer time in winter. This mode of proceeding has the effect of suspending the fermentation, in one of the hogsheads, every other day; as this process goes on in the half full hogshead only. If the fermentation was not in this way suspended, it would proceed too rapidly, and the spirituous part of the vinegar, be dissipated.

Substances which yield vinegar.

2. Besides wine, the infusion of malt, cyder, molasses, the refuse of raisins, and several other substances may be employed to produce vinegar. The fermentation, by which liquids are converted into vinegar, is called the acetous. It is not easy to discover exactly what chemical operations are going on in the process. It appears certain, however, that the presence of mucilage is absolutely necessary, and that oxygen is absorbed from the air.

Properties of vinegar.

3. Vinegar is a liquid of a reddish or yellowish colour, having an agreeable odour and pleasant sour taste. It is very liable to decomposition; but by being boiled for some time, this liability is removed. It is very little heavier than water.

Properties of acetic acid.

IV. Acetic acid, obtained by the first process given in the beginning of the present section, is in the form of a liquid, of an extremely pungent and acrid taste. It is very volatile, and, when heated in the open air, takes fire readily. It acts with considerable energy upon animal substances. When applied to the skin, it reddens and corrodes this membrane in a very short time. It combines with water in every proportion, and the union is attended by the evolution of a good deal of heat. Its specific gravity varies with the quantity of water which it may contain. It is 1·08 or a maximum, when the acid contains somewhat more than half its weight of water, and it diminishes if the acid

contain more or less than this quantity. When the acid is passed through a red-hot porcelain tube, it is partially decomposed; and if the tube be filled with charcoal, it is completely resolved into its constituents. Its combinations with salifiable bases are called acetates. These salts, when distilled with certain precautions, yield a peculiar inflammable liquid, which has been called pyro-acetic spirit. This liquid will be noticed in the following paragraphs.

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Its salts yield a spirit, when distilled.

1. Pyro-acetic spirit may be obtained by distilling an acetate, at a heat always kept as low as possible. It is exactly the same, whatever acetate may be employed. Different acetates, however, yield it in different quantities. Those acetates, whose bases are least easily deoxidized, yield the most. The acetates of soda and of potash yield a considerable portion of the spirit, and the acetate of barytes produces the spirit entirely, and no acetic acid. The pyro-acetic spirit was discovered by Chenevix.

Pyro-acetic spirit, how formed.

2. Pyro-acetic spirit is in the form of a white limpid liquid. Its taste is at first acrid and hot, but afterwards it becomes cooling, and, in some sort, urinous. Its smell is peculiar, and may be compared with that which would be produced by a mixture of oil of peppermint and bitter almonds. It is somewhat more than three fourths as heavy as water. Its boiling point is at the temperature of 165°. It is inflammable, and burns with a flame, white exteriorly, but of a fine blue colour within, leaving no residue.

Its properties.

Spec. grav. 0·78.

3. Pyro-acetic spirit combines with water, alcohol, or the volatile oils in any proportion. It dissolves a small portion of phosphorus or sulphur, and is an excellent solvent of camphor. It dissolves potash also, and forms a dark coloured liquid, from which the spirit may be separated by distillation unaltered. It is decomposed by sulphuric acid, which developes charcoal. It is altered in its properties by nitric acid, and its colour changed to yellow. It is rendered brown by hydrochloric (muriatic) acid, and by distillation may be made to combine with this acid, forming a very different compound from hydrochloric ether. The exact composition of the pyro-acetic spirit is not known.—The consideration of the acetic acid will now be resumed.

Action of different substances upon it.

V. According to an analysis, performed by Berzelius, reduced to numbers, which best accord with the atomic theory, acetic acid is composed of

Composition of acetic acid.

Carbon	24·0	—four atoms.
Hydrogen	3·2	—three atoms, nearly.
Oxygen	24·0	—three atoms.

Supposing this acid actually composed of the number of

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atoms, which appear to be indicated by the above analysis, then the number representing its atom would be 51.

Its uses in medicine.

VI. Acetic acid has several uses in medicine. In a dilute state, containing certain foreign substances, in the form of vinegar, it is used in scurvy, and for the purpose of counteracting the effects of narcotic poisons. In the form of vinegar also, when mixed with water, it furnishes a very proper drink in inflammatory fevers, and its vapour may be inhaled with advantage in sore throat. Externally applied, it forms a very useful fomentation or bath.

Several medicines are infused in vinegar, which infusions constitute what are called medicated vinegars. Of this class of remedies, there are the following officinal preparations; namely, aromatic vinegar or the vinegar of four thieves; it contains, infused, several aromatic vegetables, and formerly possessed considerable celebrity as a preventive of the plague. Also vinegar of colchicum or meadow-saffron, vinegar of squills, and camphorated vinegar. The three last mentioned medicated vinegars contain proof spirit also.

Acetic acid, in its pure state, is a pretty powerful stimulant and rubefacient. In this state, it is employed in fainting, hysteria, headache and similar affections. The manner of using it, is to snuff it up the nostrils.

SECTION IX.

OF TARTARIC* ACID.

Tartaric acid; how obtained.

I. Tartaric acid may be obtained by the following process: Dissolve bitartrate of potash (tartar) in boiling water, and add to the solution formed, carbonate of lime (chalk) in powder, as long as any effervescence should occur, or the solution redden vegetable blues. The lime of the carbonate combines with the excess of acid in the bitartrate, so as to form tartrate of lime which is insoluble, while its carbonic acid is set free, and causes the effervescence above alluded to. After the chemical action is over, the resulting substances are tartrate of lime and neutral tartrate of potash. Separate the tartrate of lime by the filter, and pour upon it as much diluted sulphuric acid, as had at first been employed of carbonate of lime, and let the mixture stand for twenty-four hours, stirring it occasionally. The sulphuric acid decomposes the tartrate, and combines with its base,

* From tartar the name of the substance, from which the acid is obtained.

so as to form insoluble sulphate of lime, which falls to the bottom of the vessel, while the tartaric acid remains in solution. Decant the solution of tartaric acid, and evaporate it slowly. Crystals will be deposited which consist of tartaric acid in a state of hydrate.

Sources in nature, and account of its discovery.

II. Tartaric acid exists ready formed, in combination with potash, in the lees of wine, and in the substance which is found incrusted upon the bottom and sides of wine casks. This substance is called tartar. It had been proved by Duhamel, Margraff and Rouelle, that tartar is composed of an acid united to potash; but the nature of the acid was altogether unknown. In 1770, Scheele succeeded in obtaining the acid of tartar in a separate state, and described many of its properties. It is this acid, under the name of tartaric acid, which furnishes the subject of the present section.

Properties of tartaric acid.

Spec. grav. 1·59.

III. Tartaric acid is in the form of crystals, white, firm, and but imperfectly transparent. Its taste is exceedingly sour. It is not altered by exposure to air. It is somewhat more than one and a half times as heavy as water. When exposed to a heat, a few degrees above the boiling point, it melts into a limpid, transparent liquid, like water. At the temperature of 250°, it boils without losing its transparency. On cooling, it concretes into a hard semi-transparent mass, having considerable resemblance to sugar, which has been exposed to the same temperature. By this exposure to heat, the acid is altered in its properties, for it now deliquesces in the atmosphere. It dissolves in water. When the solution is very dilute, the acid suffers decomposition. It combines with the greater number of the salifiable bases in two proportions. Its salts are called tartrates. When these salts are distilled at a sufficiently strong heat, the acid is decomposed, so as to form water, carbonic acid, bihydroguret of carbon (carburetted hydrogen), oil and charcoal. Hence, it is evident that its constituents are carbon, hydrogen and oxygen.

Composition of tartaric acid.

IV. According to an analysis, performed by Berzelius, calculated in proportional numbers, which best agree with the atomic theory, tartaric acid is composed of

Carbon	24·1	—four atoms, nearly.
Hydrogen	2·6	—
Oxygen	40·0	—five atoms.

Supposing this acid to contain three atoms of hydrogen, and exactly four atoms of carbon, then the number representing its atom would be 67.

V. Tartaric acid, in its pure state, is not an article of the materia medica; but combined with certain salifiable bases, it forms some very important saline medicines, to be described hereafter.

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SECTION X.

OF BENZOIC[a] ACID.

(Formerly called, *Flowers of Benzoin.—Salt of Benzoin.*)

Benzoic acid; how obtained.

I. Benzoic acid may be obtained by digesting benzoin in sulphuric acid. A crystallized substance is sublimed, which is benzoic acid.

II. Benzoin is the product of a tree, which grows in the island of Sumatra, called by the botanists, styrax benzoe. It is not, however, the only substance which yields benzoic acid. Several other substances, both animal and vegetable, have been found to furnish it also.

Its properties.

III. Benzoic acid is a fine light white powder, possessing a kind of ductility. Its taste is sweet, hot, and somewhat bitter. As usually prepared, it possesses a slight odour, which is peculiar and aromatic, and which it owes to the presence of a little aromatic oil; but, when perfectly pure, it has no smell. It suffers no alteration by exposure to air. It changes some vegetable blues to a red colour. It dissolves in 200 parts of cold water, and in 20½ parts of boiling water. It dissolves in sulphuric, sulphurous and nitric acids without alteration; and when water is added to the solutions, the benzoic acid separates and coagulates on the surface. It is not dissolved, however, by chlorine, hydrochloric acid or phosphoric acid. Its combinations with salifiable bases are called benzoates.

Composition.

IV. According to an analysis by Berzelius, reduced to numbers, which best accord with the atomic theory, benzoic acid is composed of

Carbon	29	—five atoms, nearly.
Hydrogen	2	—two atoms.
Oxygen	8	—one atom.

If this acid contained exactly five atoms of carbon, then the number representing its atom would be 40.

Medical uses.

V. At the present day, benzoic acid is seldom prescribed alone in medicine. It is, however, an ingredient in the paregoric elixirs of the British colleges. There is no reason to believe that the acid, by its presence in these preparations, adds much to their efficacy; but, having an agreeable taste and smell, it renders them less unpleasant for exhibition.

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[a] Derived from benzoin, a kind of resin brought from the East Indies, from which substance the acid was first obtained.

SECTION XI.

OF SACLACTIC* ACID.

Acid of the Sugar of Milk of Scheele.

I. SACLACTIC ACID may be obtained by the following process: Pour two parts of nitric acid upon one part of gum arabic, or other similar gum, contained in a retort, and expose the mixture to a gentle heat, until some deutoxide of azote (nitrous gas) and carbonic acid come over. The mixture, upon cooling, deposites a powder, which may be separated by the filter. This powder is saclactic acid, rendered impure by admixture of a portion of oxalate of lime, and a compound of gum and lime. The oxalate of lime may be separated by digesting the powder in diluted nitric acid; and the compound of gum and lime, by treating it with hot water, which takes up the acid alone. The hot solution thus obtained, upon cooling, deposites saclactic acid in the form of crystals. Saclactic acid; how obtained.

II. Saclactic acid may be prepared from sugar of milk.† When this substance is employed for its preparation, it is obtained pure, at once, by the action of nitric acid. Saclactic acid was discovered, in 1780, by Scheele.

III. Saclactic acid is a white, gritty powder, possessing a slightly sour taste. It is soluble in 60 parts of boiling water. The hot solution, as it cools, lets fall the acid in the form of crystals. When in solution, it reddens the infusion of turnsol. When exposed to heat, it suffers decomposition. When distilled, the products are an acid liquor, a red-coloured acrid oil, carbonic acid gas, bihydroguret of carbon, and a large proportion of charcoal. Its combinations with salifiable bases are called saclactates. Its properties.

IV. According to an analysis by Berzelius, calculated in numbers, which best agree with the atomic theory, this acid is composed of Composition.

Carbon	34·8	—six atoms, most nearly.
Hydrogen	5·3	—five atoms, nearly.
Oxygen	64·0	—eight atoms.

Supposing this acid to contain exactly six atoms of carbon and five atoms of hydrogen, then the number representing its atom would be 105.

* Abbreviated of the two Latin words, *saccharum*, sugar, and *lac*, milk; because the acid was first obtained from the substance called sugar of milk.

† Sugar of milk is a peculiar white crystallized substance, obtained from the whey of milk, to be described hereafter.

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SECTION XII.

OF CITRIC* ACID.

Crystallized Citric Acid of the Dublin College.

Citric acid; how obtained.

I. CITRIC ACID may be obtained by saturating boiling lemon juice with carbonate of lime (chalk) in powder: the carbonate becomes decomposed, its acid flies off in the state of gas, while its base combines with the pure acid of the lemon juice, so as to form the compound called citrate of lime. Separate the citrate of lime by the filter, and, after having washed it well, add to it sulphuric acid diluted with six times its weight of water, in sufficient amount to separate all the lime. Boil the mixture, thus formed, for a few minutes, and then separate the insoluble powder, which will be formed, and which consists of sulphate of lime. The remaining liquid is now a solution of citric acid. By evaporating it to the consistence of a syrup, and setting it aside to cool, the acid will be deposited in the form of crystals.

II. Citric acid exists most abundantly in the juice of oranges and lemons; but it is present in the juices of many other vegetable substances. It was first obtained in a pure state, and described accurately, by Scheele.

Its properties.

III. Citric acid, in the form of crystals, has an intensely sour taste, which becomes pleasant, when it is sufficiently diluted with water. It is not altered by exposure to air. It is exceedingly soluble in water. It dissolves in three-fourths of its weight of cold water, and in half its weight of this liquid at the boiling temperature. The solution may be kept for a long time, in close vessels; but at last it putrefies and the acid is decomposed. When the acid is subjected to the action of concentrated sulphuric acid, it is converted into acetic acid. By nitric acid, it is changed into oxalic acid; but, to produce this change, care must be taken not to use too large a quantity of nitric acid, otherwise acetic acid would be formed. When exposed to the open fire, it first melts, then swells and exhales an acrid vapour, and a quantity of charcoal is left behind. When distilled, in close vessels, it evaporates, partly unaltered, and partly decomposed into acetic and carbonic acids and bihydroguret of carbon (carburetted hydrogen), and a portion of charcoal is left behind. Its combinations with salifiable bases are called citrates.

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* From *citrus*, the Latin name for the orange tree.

IV. According to an analysis by Berzelius, calculated in numbers, which best accord with the atomic theory, citric acid is composed of (Chap. II. Composition.)

Carbon	42·2	—seven atoms, nearly.
Hydrogen	3·9	—four atoms, nearly.
Oxygen	56·0	—seven atoms.

Upon the supposition that this acid contains exactly the number of atoms, which appear to be indicated by the above analysis, then the weight of its atom would be 102.

V. Citric acid forms the important part of the acid drinks, made from the juice of lemons and limes, which are so usefully employed in inflammatory fevers. In the form of crystals, as directed to be prepared by the Dublin College, it is not liable to spoil, as when in the form of lemon juice; hence it is the best preparation of the acid for medical employment. (Medical uses.)

Of the acids, composed of carbon, hydrogen and oxygen, belonging to the present class, the ten already described are the only ones, which have been analyzed with tolerable accuracy. The atomic composition of these acids is recapitulated in the following table. (Table of the atomic composition of the ten acids last described.)

NAMES.	ATOMS OF		
	Carbon.	Hydrogen.	Oxygen.
Gallic acid.	2	1	1
Formic acid.	2	1	3
Oxalic acid.	2	1	4
Sorbic acid.	2	7	3
Succinic acid.	4	2	3
Acetic acid.	4	3	3
Tartaric acid.	4	3	5
Benzoic acid.	5	2	1
Saclactic acid.	6	5	8
Citric acid.	7	4	7

By multiplying the atoms of carbon by 6, and those of oxygen by 8, the products will be the proportional quantities of these two constituents, in the acids above enumerated. The atom of hydrogen being taken at unity, the proportional quantity of this constituent is indicated by the number of atoms themselves.

The atomic composition of some of these acids, as given by Dr. Thomson,* has not been followed in this work. (Variations from)

* Sorbic acid has been placed among the acids of this class, whose composition is known, since the above was written. Its atomic composition is deduced from a recent analysis by Vauquelin.

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Thomson's statements of the atomic composition of some of these acids, noticed, and the grounds of them explained.

The atomic composition of the oxalic acid is deduced from an analysis given by Gay-Lussac, rather than from one made by Berzelius, which cannot be employed without creating the anomaly of a fractional atom of hydrogen, or deducing a disproportional atomic amount for the other constituents of this acid. The atomic composition of citric acid is given differently from Dr. Thomson; because the hydrogen of the acid is given by this chemist theoretically, and not in accordance with actual analysis. Dr. Thomson gives the gallic acid, as composed of six atoms of carbon, three atoms of hydrogen, and three atoms of oxygen; which composition, if I understand the atomic theory right, in nowise differs from two atoms of carbon, one atom of hydrogen and one atom of oxygen, or Dr. Thomson's numbers, reduced to their lowest terms. For a similar reason, benzoic acid is given as a compound of five atoms of carbon, two atoms of hydrogen, and one atom of oxygen, instead of Dr. Thomson's numbers of fifteen atoms of carbon, six atoms of hydrogen and three atoms of oxygen.

By possibility, indeed, two ternary compounds of the same ultimate constituents, united in the same proportions, may not be identical, in consequence of some variation, between them, in the predisposing binary combinations of their constituents: and, taking this view of the subject, Dr. Thomson's atomic compositions for citric and benzoic acids may differ from those here adopted. But, however this question may be decided in the abstract, it is believed that no instance can be adduced of two substances, agreeing in the way here mentioned, which are not identical.

The atomic compositions of the ten acids, last described, have not been given, under the influence of a belief that much dependence can be placed upon their accuracy; but as approximations only, which may be received, until corrected by more exact observations.

Explanation of the manner in which the atoms of ternary compounds may combine.

Three atoms of different bodies cannot be conceived to unite together as atoms. Two of them must first combine together, and the new atom, thus formed, may then combine with the third. Neither can an unequal number of atoms of three different substances unite together, without the supposition being necessary of a previous binary combination. The atoms of two of the substances, after having combined together, may then unite with the atoms of the third: or the atoms of any two of the substances may separately combine with atomic portions of the third, and the two binary compounds, thereby formed, may afterwards unite; but in no other way, in the case here supposed, is it probable that a union can take place by atoms. Taking this

view of the subject, therefore, it is very probable that all the acids of this class, except the two first, are compounds, in different proportions, of carbonic oxide or carbonic acid, with the two hydrogurets of carbon, modified by the presence of different portions of water. Chap. II.

The description of the remaining acids, embraced by the fifth class, will now be resumed.

SECTION XIII.

OF MELLITIC* ACID.

Mellitic acid; how obtained.

I. Mellitic acid may be obtained by boiling the mineral called mellite, which is composed of this acid and alumina, in a state of powder, in seventy-two times its weight of boiling water. The mellitic acid dissolves in the water and the alumina separates in flakes. Remove the alumina by the filter, and evaporate the clear solution, until it form crystals. These crystals will consist of mellitic acid.

Exists only in mellite.

II. Mellitic acid has heretofore been found only in the mineral called mellite. This mineral has usually a honey-yellow colour, but sometimes a straw-colour. It is crystallized, generally smooth and brilliant, and presents, when broken, the glassy fracture. It has some resemblance to amber. It is partly combustible. It is an exceedingly rare mineral, having been heretofore found only in Thuringia and Switzerland. It was first analyzed, and a peculiar acid found to be one of its constituents, by Klaproth in 1799.

Its properties.

III. Mellitic acid, in the form of crystals, has a brownish colour, and a taste, at first sweetish-sour, but afterwards bitterish. It is very soluble in water. When exposed to heat, it emits abundance of smoke, without smell, and the residue is a small quantity of insipid ashes. It combines with some of the salifiable bases, and forms salts called mellates. Its exact composition has not been made out; but there is no doubt that it is a compound of carbon, hydrogen and oxygen.

* This acid has its name from the mineral called mellite. The name of this mineral is derived from *mel*, Latin for honey, on account of its honey-yellow colour.

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SECTION XIV.

OF CAMPHORIC ACID.

Camphoric acid; how obtained.

I. CAMPHORIC ACID may be obtained by distilling together, one part of camphor, and eight parts of nitric acid, at a sand heat: a good deal of deutoxide of azote (nitrous gas) and carbonic acid are extricated. As soon as all the nitric acid has come over, the same quantity, as first employed, is to be distilled off the camphor, at two successive distillations. After the retort has become cool, a number of crystals will make their appearance. These crystals consist of camphoric acid. This acid was discovered by Kosegarten, in 1785.

Its properties.

II. Camphoric acid, in the form of crystals, has a snow-white colour, a slightly sour, bitter taste, and a smell resembling that of saffron. It reddens vegetable blues. When exposed to the air, it effloresces. It dissolves in ninety-six parts of water, at the temperature of 60°, and in eleven parts of boiling water. It is soluble in hydrochloric, sulphuric and nitric acids. When distilled, it first melts, and then sublimes unaltered. When placed on ignited coals, it emits dense aromatic fumes, and is entirely dissipated. It combines with some of the salifiable bases, and forms salts called camphorates. Its constituents are carbon, hydrogen and oxygen.

SECTION XV.

OF MALIC* ACID.

Malic acid; how obtained.

I. MALIC ACID may be obtained by the following process: Saturate the juice of apples with carbonate of potash, and, to the liquid obtained, add acetate of lead (sugar of lead) as long as any precipitate should appear: the precipitate formed will be a compound of malic acid and protoxide of lead. Separate it by the filter, and, after having washed it carefully, pour upon it, diluted sulphuric acid, until the solution formed has a perceptibly sour taste: the added acid will combine with the protoxide of lead, and precipitate in the form of sulphate of lead. After this sulphate is removed by the filter, the remaining liquid will be a solution of malic acid.

* From *malum*, the Latin word for apple; because the malic acid was first obtained from the juice of this fruit.

II. Malic acid may be obtained from other substances, besides the juice of apples. It exists in abundance in the juice of the house-leek (sempervivum tectorum); in which plant, it is combined with lime. It may be procured from sugar, by distillation with its own weight of nitric acid. It was discovered in 1785 by Scheele. Chap. II. Substances which furnish it.

III. Liquid malic acid has a reddish-brown colour, and a very sour taste. When evaporated, it does not crystallize, but becomes thick and viscid, resembling a syrup. When exposed to a dry atmosphere, in thin layers, it dries entirely, and assumes the appearance of varnish. It is very soluble in water. When acted upon by sulphuric acid, it is charred, but by nitric acid, it is converted into oxalic acid. When subjected to distillation, the products are an acid water, a little bihydroguret of carbon, and a large quantity of carbonic acid. When heated in the open fire, it turns black, and emits acrid fumes, and a voluminous charcoal is left behind. Hence it is evident that this acid is a compound of carbon, hydrogen and oxygen. Its combinations with salifiable bases are called malates. Its properties.

SECTION XVI.

OF LACTIC* ACID.

I. Lactic acid may be obtained by the following process: Evaporate sour whey to one-eighth, and separate the cheesy part by the filter. Precipitate the phosphate of lime, present in the remaining liquid, by means of lime water. Separate any lime, which may have been dissolved, by means of oxalic acid. Evaporate the liquid, as it now stands, to the consistency of honey, and treat it with alcohol: This liquid dissolves the lactic acid alone, and leaves every thing else untouched. To the alcoholic solution of the acid, add a small quantity of water, and distil with a moderate heat: the alcohol is driven over, so that nothing remains in the retort but a solution of lactic acid in water. Lactic acid; how obtained.

II. Lactic acid was discovered, in 1780, by Scheele. Its existence was afterwards doubted, and several chemists supposed that they had proved it to be acetic acid, contaminated with some foreign matters. In 1808, Berzelius subjected the acid to a thorough investigation, which terminated in completely establishing its peculiar nature.

* From *lac*, the Latin word signifying milk; it being this liquid from which lactic acid is procured.

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Its properties.

III. Lactic acid is in the form of a liquid, having a brownish-yellow colour, and a sharp sour taste. It has no smell when cold, but when heated, it emits a sharp sour odour, not unlike that of sublimed oxalic acid. It is not capable of crystallizing. When evaporated to dryness, it assumes the appearance of a smooth varnish. When distilled, it is converted into empyreumatic oil, water, acetic acid, carbonic acid and inflammable gas. When heated in the open fire, it boils, emits a sour smell, and leaves a bulky charcoal. It combines with some of the salifiable bases and forms salts called lactates. Its constituents are carbon, hydrogen and oxygen; but the proportion, in which these bodies are combined is not known.

SECTION XVII.

OF PYROTARTARIC* ACID.

Pyrotartaric acid; how obtained.

I. Pyrotartaric acid may be obtained by the following process: Distil a quantity of bitartrate of potash (tartar), and, after saturating the acid liquor which will be obtained with potash, let it stand to crystallize. The crystals, which form, consist of the acid under description, combined with potash; they may be purified by repeated solution and crystallization. By distilling these crystals with diluted sulphuric acid, they are decomposed, sulphate of potash becomes formed, and the pyrotartaric acid passes over into the receiver, where it condenses into a liquid; when this liquid is exposed to spontaneous evaporation, the acid is deposited in the form of crystals.

Its history.

II. Pyrotartaric acid, in an impure state, was known before tartaric acid. Tartar had been long considered an acidulous salt, whose base was easily shown to be potash by combustion. When distilled, it yielded an acid liquor; but this was evidently not the acid of tartar, since it did not form tartar by combining with potash. This inference was subsequently fully confirmed, in 1770, by Scheele, who discovered the true acid of tartar. The acid liquor thus obtained from tartar, although different from tartaric acid, yet appearing to possess peculiar properties, the French chemists, when they adopted their new nomenclature, gave it the name of pyrotartaric acid. Its peculiar

* From πυρ, fire, and tartar, the name of the salt from which this acid is obtained by the action of fire.

nature was afterwards, in 1799, called in question by Fourcroy and Vauquelin, who supposed they had proved it to be acetic acid, disguised by admixture of empyreumatic oil. This conclusion of the French chemists was combated, in 1806, by Gehlin, who revived the original opinion of its peculiar nature. In consequence of the experiments of this chemist, Fourcroy and Vauquelin submitted the acid liquor to a new examination, which terminated in confirming the conclusions of Gehlin. Chap. II.

III. Pyrotartaric acid is in the form of crystals, and possesses an extremely sour taste. It is readily soluble in water, and the solution formed deposites crystals by spontaneous evaporation. When heated, it melts, and sublimes in the form of a thick smoke, without leaving any residue. It combines with some of the salifiable bases, forming salts called pyrotartrates. Its ultimate constituents are carbon, hydrogen and oxygen; but the proportion in which they are united is not known. Its properties.

SECTION XVIII.

OF MOROXYLIC* ACID.

I. Moroxylic acid may be obtained by the following process: Dissolve the saline exudation, found on the bark of the white mulberry tree, in water, and let the solution stand, until it deposite crystals. These crystals will be small and needle-form, and consist of a salt composed of the acid under description and lime. After a sufficient number of them have been deposited, dissolve them in water, and add to the solution formed, acetate of lead (sugar of lead). This addition decomposes the moroxylate of lime, and causes a moroxylate of lead to precipitate. Separate the moroxylate of lead, and decompose it by means of sulphuric acid, diluted with twice its weight of water. The lead falls in combination with this acid, in the form of an insoluble sulphate of lead; while the moroxylic acid remains in solution. Separate the sulphate of lead, and evaporate the clear solution, until crystals make their appearance. The crystals, which will form, consist of moroxylic acid. This acid was discovered, in 1803, by Klaproth. Moroxylic acid; how obtained.

II. Moroxylic acid is in the form of fine needle-shaped Its properties.

* From morus, the mulberry tree, and ξύλον, wood.

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crystals, of a pale wood colour. Its taste is similar to that of succinic acid. It is soluble in water. It suffers no alteration by exposure to the air. When distilled, an acid liquor is first driven over, and afterwards part of the acid sublimes unaltered upon the upper part and the neck of the retort. What remains behind is a coaly residuum. Its combinations with salifiable bases are called moroxylates. Its ultimate constituents are carbon, hydrogen and oxygen.

SECTION XIX.

OF SUBERIC* ACID.

Suberic acid; how obtained.

I. SUBERIC ACID may be obtained by the following process: Digest one part of cork in six parts of nitric acid. After the action of the acid is over, evaporate the mixture to the consistence of an extract, dilute it with water, and then expose it, for some time, to a sand heat. The liquid, thus obtained, by being set aside, forms on its surface a substance resembling wax, and deposites white flocks at its bottom. Both these substances must be separated, and the remaining liquid, concentrated by evaporation. As the concentration proceeds, a powder falls, which, after being washed with cold water, is pure suberic acid. This acid was discovered, in 1787, by Brugnatelli.

Its properties.

II. Suberic acid is in the form of a white powder, having some resemblance to starch. Its taste is sour, without any mixture of bitterness. It dissolves in 80 parts of water, at the temperature of 55·5°, and in 38 parts, at the temperature of 140°. When exposed to heat, it first melts, and then sublimes. Its combinations with salifiable bases are called suberates. Its ultimate constituents are carbon, hydrogen and oxygen.

SECTION XX.

OF LACCIC ACID.

Laccic acid, obtained from lac.

I. VERY little is known respecting laccic acid. It was obtained, by John, from stick-lac, a substance which comes from the East Indies. This substance has been ascertained

* From *suber*, the Latin name for cork.

to constitute the nidus of a certain insect, called chremes lacca. When chemically examined, it is found to consist principally of resin.

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Its properties.

II. Laccic acid has a wine-yellow colour, and a sour taste. It is soluble and crystallizable. Its combinations with salifiable bases are called laccates. Its ultimate constituents are carbon, hydrogen, and oxygen.

SECTION XXI.

OF KINIC* ACID.

Kinic acid; how obtained.

I. Kinic acid may be obtained by the following process: Macerate yellow Peruvian bark in cold water, and concentrate the infusion formed by evaporation. Let it stand for some time, until crystals make their appearance. Separate the crystals which form, and purify them by repeated crystallizations: they consist of the acid under description, combined with lime. In order to obtain the kinic acid in a separate state, dissolve the crystals in water, and add oxalic acid to the solution formed. This acid separates the lime, in the form of an insoluble oxalate of lime, while the kinic acid remains in solution. Kinic acid was discovered by Vauquelin, combined with lime, in a salt, prepared from Peruvian bark, by Deschamps, junior, an apothecary of Lyons. Deschamps' salt was, therefore, a kinate of lime.

Its properties.

II. Kinic acid, in the form of solution, has a brown colour, and a sour and somewhat bitter taste. It is not altered by exposure to air. When concentrated, by evaporation, to the consistency of a syrup, it does not crystallize spontaneously, but instantly, upon being touched with a glass rod. When exposed to the action of heat, on burning coals, it first melts, then froths and blackens, and afterwards exhales an acrid vapour. The residuum is a small portion of charcoal. Its ultimate constituents are carbon, hydrogen, and oxygen.

* Contracted of *quinquina*, the French name for the Peruvian bark.

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SECTION XXII.

OF ZUMIC* ACID.

Zumic acid; how obtained.

I. Zumic acid may be obtained by the following process: Allow a mixture of rice and water to ferment; and evaporate the liquid thus procured, after being strained, almost to dryness, so as to form a gummy mass. Digest the gummy mass in alcohol, and evaporate the solution formed, until crystals make their appearance. These crystals consist of zumic acid combined with a portion of lime. Separate them and dissolve them in water, and, to the solution formed, add barytes water as long as any precipitate ensues: the barytes combines with the zumic acid, and remains in solution, while the lime is precipitated. Separate the lime by the filter, and add to the clear solution sulphuric acid, in just sufficient quantity to precipitate all the barytes of the zumate of barytes. The precipitate thus formed being separated, nothing remains but a solution of zumic acid.

II. Zumic acid was lately discovered by Braconnot, by treating rice in the manner just detailed. It is not, however, peculiar to the fermentation of rice, but appears to be formed pretty generally by the spontaneous fermentation of vegetable substances.

Its properties.

III. Zumic acid is a colourless liquid, possessing a very sour taste. It is incapable of crystallization; but, upon sufficient evaporation, it forms a syrup. When subjected to distillation, it yields charcoal and acetic acid. Hence its constituents must be carbon, hydrogen and oxygen. Its combinations with salifiable bases are called zumates by Dr. Thomson.†

SECTION XXIII.

OF BOLETIC‡ ACID.

Boletic acid.

I. Boletic acid was discovered, in 1811, by Braconnot, in the expressed juice of the boletus pseudo-igniarius.

* *Zumic* is the name given to this acid by Dr. Thomson, instead of *nanceic*, derived from Nancy, the name of the city in which its discoverer resides. Dr. Thomson's name is derived from ζυμη leaven.

† I find, by a notice contained in the Annals of Philosophy, Vol. XII. p. 391, that the peculiar nature of zumic acid has been called in question by Vogel. This chemist informs us that he has obtained it from different species of corn, and finds it, when properly purified, to be the lactic acid of Berzelius.

‡ From *boletus*, the Latin name for the mushroom.

It is a crystallized solid, of a white colour. Its taste is similar to that of bitartrate of potash (tartar). When in the state of solution, it reddens vegetable blues. It is not altered by exposure to air. It dissolves in 180 parts of water at the temperature of 68°. When distilled, the greatest part of it sublimes unaltered. When exposed to the action of the open fire, it rises in white vapours, which irritate the throat, and condense on surrounding bodies, in the form of a farinaceous powder. Its combinations with salifiable bases are called boletates. Its ultimate constituents are probably carbon, hydrogen, and oxygen.

Having thus finished the consideration of the acids, in conformity with the plan pursued with regard to the other sets of chemical bodies, their principal properties will be recapitulated in a series of tables.

I. *Table of Acids, whose Bases form Acid Compounds by combining with Oxygen or Hydrogen indifferently.*

Names adopted in this work	Old names or Synonymes.	Discoverers, and time of discovery.	State as to aggregation.	Colour.	Smell.	Taste.	Solubility.	Effects of exposure to air.	Specific Gravity. Compared with air.	Specific Gravity. Compared with water.	Effects of heat or cold.	Composition.	Weight of an atom of each.
1. Chloric Acid.	Hyperoxymuriatic acid.	Gay-Lussac, in a separate state; 1814.	Liquid.	Colourless.	None, unless when concentrated.	Very acid.						Chlorine one atom. 36 Oxygen five atoms. 40	
2. Oxychloric Acid.	Perchloric acid of Dr. Thomson.	Count Von Stadion.	Liquid.									Chlorine one atom. 36 Oxygen seven atoms. 56	
3. Hydrochloric Acid.		Composition ascertained by Gay-Lussac and Thenard.	Gaseous.	Invisible.	Peculiar.	Very sour.	Forms, with water, liquid hydrochloric acid.					Chlorine one atom. 36 Hydrogen one atom. 1	
3. Liquid Hydrochloric Acid.	Muriatic acid. Marine acid. Spirit of Sea Salt.		Liquid.	Colourless when perfectly pure.	The same as that of the gaseous acid.			Combines with moisture, and appears in white fumes.				When a saturated solution, water 1 vol. acid gas 515 vol.	
4. Iodic Acid.		H. Davy.	Solid.	White and semi-transparent.	None.	Astringent and sour.	Readily soluble.	Deliquescent in a moist air.				Iodine one atom. 125 Oxygen five atoms. 40	
5. Hydriodic Acid.		Clement	Gaseous.	Invisible.	Like that of hydrochloric acid.	Very sour.	Readily absorbable by water.					Iodine one atom. 125 Hydrogen one atom. 1	
6. Sulphuric Acid.	Absolute sulphuric acid.		Solid, below the temp. of 66°.	In the solid form, like asbestos.			Dissolves in water, with which it forms liquid sulphuric acid.	Fumes and flies off in vapour.				Sulphur one atom. 16 Oxygen three atoms. 24	
6. Liquid Sulphuric Acid.	Vitriolic acid. Oil of Vitriol.		Liquid of an oily consistency.	Colourless.	Nearly none.	Intensely sour.		Attracts moisture and becomes heavier.		Maximum, 1·85.	Boils at 620°, max. Freezes at −36°, max.	Sulphuric acid, combined with various quantities of water.	

Table of Acids, whose Bases form Acid Compounds by combining with Oxygen or Hydrogen indifferently—Concluded.

Names adopted in this work.	Old names or Synonymes.	Discoverers, and time of discovery.	State as to aggregation.	Colour.	Smell.	Taste.	Solubility.	Effects of exposure to air.	Specific Gravity.		Effects of heat or cold.	Composition.	Weight of an atom of each.
									Compared with air.	Compared with water.			
7. Sulphurous Acid.		Scheele and Priestley; 1774.	Gaseous.	Invisible.	Strong and suffocating.	Very acid and sulphurous.	Water takes up 33 times its volume of the gas.				Condenses	Sulphur one atom. 16 Oxygen two atoms. 16	32
8. Hyposulphurous Acid.			Not yet obtained in a separate state.									Supposed to be Sulphur one atom. 16 Oxygen one atom. 8	24
9. Hydrosulphuric Acid.	Sulphuretted Hydrogen. Hydrothionic acid of the Germans.	Scheele; 1777.	Gaseous.	Invisible.	Strong and fetid.		Water takes up 3¼ times its volume of the gas.					Sulphur one atom. 16 Hydrogen one atom. 1	17
10. Hydrosulphurous Acid.	Hydroguretted Sulphur. Supersulphuretted Hydrogen.	Scheele.	Liquid resembling oil.	Yellowish-brown.								Sulphur. Hydrogen.	
11. Selenic Acid.		Berzelius.	Solid.			Acid and burning.	Readily soluble.					Selenium one atom. 40 Oxygen two atoms. 16	56
12. Hydroselenic Acid.		Berzelius.	Gaseous.	Invisible.	Acts with violence on the sense of smell.		Dissolves in water, totally deprived of air.					Selenium 37 Hydrogen one atom. 1	
13. Telluric Acid.	Oxide of Tellurium.		Powder.	White.								Tellurium one atom. 32 Oxygen one atom. 8	40
14. Hydrotelluric Acid.	Telluretted Hydrogen.	H. Davy; 1809.	Gaseous.	Invisible.	Strong and peculiar.		Forms a claret-coloured solution.						

II. *Table of Acids, whose Bases form Acid Compounds by combining with Oxygen only.*

Names.	Old names or Synonymes.	Discoverers, and time of discovery.	State as to aggregation.	Colour.	Smell.	Taste.	Solubility.	Effects of exposure to air.	Specific Gravity.	Effects of heat or cold.	Composition.	Weight of an atom of each.
1. Nitric Acid.	Spirit of Nitre. Aqua Fortis.	Raymond Lully; 13th century. Composition discovered by Cavendish.	Liquid.	Transparent and colourless.	Its fumes, acrid and disagreeable.	Exceedingly acrid.	It has never been obtained free from water.	Attracts moisture.	Maximum, 1·55.	Maximum boiling point, 248°. Freezing point, −66°.	Azote one atom. 14 Oxygen five atoms. 40	
2. Nitrous Acid.		Scheele.	Very volatile liquid.	Orange-coloured.		Very sour.	Decomposed by water.	Emits fumes.	1·451.	Boiling point,	Azote one atom. 14 Oxygen four atoms. 32	
3. Hyponitrous Acid.	Pernitrous Acid of Gay-Lussac.	Existence made probable by Gay-Lussac.									Supposed to be Azote one atom. 14 Oxygen three atoms. 24	
4. Carbonic Acid.	Fixed Air. Aerial Acid. Mephitic Acid. Calcareous Acid.	Black; 1756. Composition discovered by Lavoisier.					Water, at 55°, absorbs a little more than its bulk.		1·527		Carbon one atom. 6 Oxygen two atoms. 16	
5. Boracic Acid.	Sedative or Narcotic Salt of Homberg.	Homberg; 1702. Composition discovered by Gay-Lussac & Thenard and H. Davy.									Boron. Oxygen.	
6. Phosphoric Acid.		Composition discovered by Lavoisier.								Melts at a red heat. After fusion, called phosphoric glass.	Phosphorus one atom. 12 Oxygen two atoms. 16	
7. Phosphorous Acid.		First obtained pure by H. Davy.								When heated, catches fire.	Phosphorus one atom. 12 Oxygen one atom. 8	

Table of Acids, whose Bases form Acid Compounds by combining with Oxygen only—Continued.

Name	Old names	Discoverer, and	State as t ggregatio			Taste.	Solubility.	Effects of exposure to air.	Specific Gravity	Effects of heat.	Composition.	Weight of an atom of each.
8. Hypopl phorou Acid.			Liquid; viscid whe ncentrate			Very sour.	Always contains water.	Absorbs oxygen.		Decomposed.	Phosphorus 24 two atoms. Oxygen 8 one atom.	
9. Arseni Acid.			Solid.			Scarcely any, when dry. In solution, acrid and metallic.	Dissolves in 6 parts of cold water, and in 2 parts of hot.	Attracts moisture.	[illegible]	Melts into a glass, and emits oxygen.	Arsenic 46 Oxygen 24 three atoms.	
10. Arsen Acid.			Compact solid.	White.	When heated like that of garlic.	Sharp and acrid, with some sweetness.	Dissolves in 80 parts of cold water, and in 14 parts of hot.		3·70.	Sublimes at the temp. of 383°. Melts in close vessels.	Arsenic 47 one atom. Oxygen 16 two atoms.	
11. Chro Acid.		Vauquel 1797.				Acrid, sharp and metallic.	Soluble.	Absorbs moisture slowly.		Gives out oxygen gas.	Chromium 28 one atom. Oxygen 24 three atoms.	
12. Molyl Acid.		Scheele 1778.					Dissolves in 960 parts of boiling water.			In the open air, sublimes; in close ves-	Molybdenum 48 one atom. Oxygen 24 three atoms.	
13. Molyb Acid.							Soluble.				Molybdenum 48 one atom. Oxygen 16 two atoms.	
14. Tung Acid.		Scheele; 1781.	Powder.	Yellow			Insoluble.				Tungsten 96 one atom. Oxygen 24 three atoms.	

Table of Acids, whose Bases form Acid Compounds by combining with Oxygen only—Concluded.

Names.	Old names or Synonymes.	Discoverer, and time of discovery.	State as to aggregation.	Colour.	Smell.	Taste.	Solubility.	Effects of exposure to air.	Specific Gravity.	Effects of heat.	Composition.	Weight of an atom of each.
15. Columbic Acid.		Hatchett; 1801.	Powder.	White.			Insoluble.				Columbium one atom. 146 Oxygen one atom. 8	154
16. Antimonic Acid.			Powder.	Straw-coloured.			Insoluble.			At a red heat, gives out oxygen gas.	Antimony. Oxygen.	
17. Antimonious Acid.	Argentine Flowers of Antimony.			Fine white.			Insoluble.			Fuses at a pretty high heat.	Antimony. Oxygen.	

III. *Table of Acids, whose Bases form Acid Compounds by combining with Hydrogen only.*

Names adopted in this work.	Usual chemical names.	Discoverers, and time of discovery.	State as to aggregation.	Colour.	Smell.	Taste.	Solubility.	Effects of exposure to air.	Specific Gravity.	Effects of heat or cold.	Composition.	Weight of an atom of each.
1. Hydrofluoric Acid.	Fluoric acid.	First obtained pure by Gay-Lussac and Thenard; 1808. Constituents made probable by Ampere and H. Davy.	Liquid.	Colourless.	Like that of hydrochloric acid, but stronger.	Not known; very corrosive.	Combines with water violently, evolving heat.	Fumes violently, and is dissipated.	1·06.	Boiling point, very low. Freezing point, lower than −4°.	Constituents supposed to be a peculiar radical and hydrogen.	
2. Hydrocyanic Acid.	Prussic acid.	True nature discovered by Gay-Lussac; 1815.	Liquid.	Colourless.	Strong; like that of peach blossoms.	Sharp; at first cooling, but afterwards burning.	Combines with water.		At the temp. of 64·5°, 0·69. As vapour, 0·94.	Boiling point, 79·7°. Freezing point, 5°.	Cyanogen one atom. 26 Hydrogen one atom. 1	27

IV. *Table of Acids of Irregular Constitution.*

Names adopted in this work.	Usual chemical names, or Synonymes.	Discoverers, and time of discovery.	State as to aggregation.	Colour.	Smell.	Taste.	Solubility.	Effects of exposure to air.	Specific Gravity.	Composition.		Weight of an atom of each.
1. Chlorocarbonic Acid.	Phosgene gas of J. Davy.	J. Davy 1812.			Like the ...ed odours ...f chlorine and ...mmonia.		Decomposed by water into hydrochloric and carbonic acids.	Emits very strong and suffocating fumes.		Carbonic oxide one atom. Chlorine one atom.	14 38	[redacted]
2. Chloriodic Acid.	Chloruret of Iodine of Gay-Lussac.	H. Dav... and Gay-Lus...					Forms a colourless solution.	Deliquesces.		Chlorin... Iodine.		
3. Borofluoric Acid.	Fluoboric acid of Gay-Lussac.	Gay-Lus... and Thenar... 1808.			Like that of ...ydrochloric acid.	Exceedingly acid.	Water absorbs 700 times its bulk, and becomes 4.4ths heavier.	.	2·37.	Boron. Fluorin...		
4. Silicofluoric Acid.	Silicated Fluoric Acid. Fluosilicic Acid. Fluoric Acid of Scheele.	Discovered Scheele True nature out by J. Davy			Like ... of ...droch... acid					Supp... ... Silicum. Fluorin...		
5. Chlorocyanic Acid.	Oxyprussic Acid of Berthollet.	Discovered Bertholl... True nature out by Gay-L... 1815.			Peculi...					Cyanog... one at... Chlorin... one at...		
6. Sulphocyanic Acid.	Sulphuretted Chyazic Acid of Porrett. Anthrazothionic Acid of Grotthuss.	Porrett 1808.			Stron... ...ke the ...cetic ...					Hydroc... one at... Sulphur		
7. Ferrocyanic Acid.	Ferruretted Chyazic Acid of Porrett.	Porrett 1814.			Non...					Accordi... Carbon Azote Hydrog... Iron		

V. *Table of Acids, in which Oxygen and Hydrogen are both present.*

Names.	From what substances usually obtained.	Discoverers and time of discovery.	State as to aggregation.	Colour.	Smell.	Taste.	Solubility.	Effects of exposure to air.	Specific Gravity.	Effects of heat or cold.	Composition.	Weight of an atom of each.
1. Uric Acid.	Certain urinary concretions.	Scheele; 1776.	Powder.	White.	None.	None.	Dissolves in 17? parts of cold wa-ter, and in 11? parts of hot.			Decomposed when distilled.	Azote 14—one atom. Carbon 12—two atoms. Hydrogen 1—one atom. Oxygen 8—one atom.	36
2. Purpuric Acid.	Uric acid; by the action of nitric acid.	Prout; 1818.	Fine powder.	Slightly yellowish.			Very sparingly soluble.			By heat, becomes purple and consumes.	Azote 14—one atom. Carbon 12—two atoms. Hydrogen 2—two atoms. Oxygen 16—two atoms.	44
3. Gallic Acid.	Oak-galls.	Dijon Academicians; 1777.	Crystals.	Transparent.	Unpleasant aromatic, when heated.	Sour, with astringency.	Dissolves in 1 parts of cold wa-ter, and in t of hot.				Carbon 11·3— Hydrogen 1·0—one atom. Oxygen 8·0—one atom.	21?
4. Formic Acid.	The red Ant.	Margraff; 1749.	Liquid.		Sharp sour.					Not crystallizable by cold.	Carbon 12·0—two atoms. Hydrogen 1·0—one atom. Oxygen 24·0—three atoms.	37?
5. Oxalic Acid.	Sugar, Gum, Honey, &c.	Bergman and Scheele.	Crystals.	Fine white with lustre.		Very acid.	Dissolves in 2 parts of cold wa-ter, and in 1 par of hot.			By a gentle heat, loses water and falls to powder.	Carbon 12·0—two atoms. Hydrogen 1·2— Oxygen 32·0—four atoms.	45?
6. Sorbic Acid.	Juice of the berries of the Mountain Ash.	Donovan; 1815.	Liquid.	Colourless.	None.	Intensely sour.					Carbon 11·7— Hydrogen 7·0—seven atoms Oxygen 23·3—	42?
7. Succinic Acid.	Amber.	Boyle first remarked its acid properties.	Crystals.	White.		Acid.	Dissolves in 9? parts of cold wa-ter, and in 2 parts of hot.			By a sand bath heat, melts and sublimes.	Carbon 24·0—four atoms. Hydrogen 3·3— Oxygen 24·0—three atoms	50?
8. Acetic Acid.	Acetates, by distillation.		Volatile Liquid.			Extremely pungent and acrid.	Combines with water in any proportion.		Maximum 1·08.	When heated, takes fire readily.	Carbon 24·0—four atoms. Hydrogen 3·3— Oxygen 24·0—three atoms.	51?

Table of Acids, in which Oxygen and Hydrogen are both present—Continued.

Names.	From what substances usually obtained.	Discoverers, and time of discovery.	State as to aggregation.	Colour.	Smell.	Taste.	Solubility.	Effects of exposure to air.	Specific Gravity.	Effects of heat or cold.	Com
9. Tartaric Acid.	Tartar.	Scheele; 1770.	Crystals.	White.		Exceedingly sour.	Soluble.				Carbon Hydrogen Oxygen
10. Benzoic Acid.	Benzoin.		Fine light Powder.	White.	None, when pure.	Sweet, hot and somewhat bitter.	Dissolves in 300 parts of cold water, and in 20·5 of hot.				Carbon Hydrogen Oxygen
11. Saclactic Acid.	Sugar of milk and gum, by the action of nitric acid.	Scheele; 1780.	Gritty Powder.	White.		Slightly sour.	Dissolves in 60 parts of boiling water.				Carbon Hydrogen Oxygen
12. Citric Acid.	The juice of oranges and lemons.	Scheele.	Crystals.			Intensely sour.	Dissolves in three-fourths of its weight of cold water, and in half its weight of hot.				Carbon Hydrogen Oxygen
13. Mellitic Acid.	The mineral called mellite.	Klaproth; 1799.	Crystals.	Brownish.		At first sweetish-sour, then bitterish.	Very soluble.				Carbon. Hydrogen. Oxygen.
14. Camphoric Acid.	Camphor.	Kosegarten. 1785.	Crystals.	Snow-white.	Like that of saffron.	Slightly sour, and bitter.	Dissolves in 96 parts of cold water, and in 11 parts of hot.	ees.		and then sublimes.	Carbon. Hydrogen. Oxygen.
15. Malic Acid.	The juice of apples or of the house-leek.	Scheele; 1785.	Viscid Liquid.	Reddish-brown.		Very sour.	Very soluble.	In a dry air, becomes like varnish.			Carbon. Hydrogen. Oxygen.
16. Lactic Acid.	The whey of milk.	Scheele; 1780.	Liquid.	Brownish-yellow.	Sharp sour, when heated.	Sharp sour.	..			When evaporated to dryness, appears like varnish.	Carbon. Hydrogen. Oxygen.

Table of Acids, in which Oxygen and Hydrogen are both present—Concluded.

Names.	From what substances usually obtained.	Discoverer, and time of discovery.	Sta[illegible]	Taste.	Solubility.	Effects of exposure to air.	Specific Gravity.	Effects of heat or acids.	Composition.	Weight of an atom of each.
17. Pyrotartaric Acid.	Tartar, by distillation.		C[illegible]	xtremely sour.				By heat, melts, nd sublimes in a thick smoke.	Carbon. Hydroge Oxygen.	
18. Moroxylic Acid.	The exudation on the bark of the mulberry.	Klaproth, 1803.	C[illegible]	Like that succinic acid.					Carbon. Hydroge Oxygen.	
19. Suberic Acid.	Cork.		P[illegible] like	our, withut any ttemess.				By heat, melts and sublimes.	Carbon. Hydroge Oxygen.	
20. Laccic Acid.	Stick-lac.		C[illegible]	Sour.					Carbon. Hydroge Oxygen.	
21. Kinic Acid.	Peruvian Ba[illegible]		Liquid.	Sour and somewhat bitter.				By heat, may be ncentrated to the onsistence of a syrup.	Carbon. Hydroge Oxygen.	
22. Zumic Acid.	Vegetable substances, b fermentatio[illegible]		Syrupy Liquid.	Very sour.				When distilled, nverted into acea acid and charcoal.	Carbon. Hydroge Oxygen.	
23. Boletic Acid.	A species o Mushroom.		Crystals.	Like that of bitartrate of potash.				When distilled, part sublimes unaltered.	Carbon. Hydroge Oxygen.	

CHAPTER III.

ACIDS DEFINED, AND THE CLASSIFICATION OF THEM PURSUED IN THE PRESENT WORK EXPLAINED.

Having now finished the consideration of the acids, and given a tabular view of their properties, the reader is prepared to understand what is meant, in a chemical sense, by the term *acid*.

Definition of acids.

The term *acid*, as used by the chemist, has a very different meaning from its common acceptation. In common language, this term is used as synonymous with sour; but when employed by the chemist, it is applied to a class of substances, which have either or both of the following properties.

1. A sour taste.

2. The property of combining with certain compounds, called salifiable bases, with the effect of destroying their distinctive properties, as well as of losing their own.

Acids of doubtful character enumerated.

The second property mentioned may be considered as the most distinctive of acids. It is possessed by all this class of chemical bodies, except, perhaps, hydrocyanic (prussic) acid, chloriodic acid and chlorocyanic acid. Chlorocarbonic acid is found to be capable of neutralizing four times its volume of ammoniacal gas; and although it is not known to be capable of combining with any other salifiable base; yet this one combination is sufficient to establish its acid nature.

In strict propriety, perhaps, hydrocyanic acid should not stand among the acids. Acid properties were first attributed to it, under the influence of the erroneous opinion, that it is capable of neutralizing, or destroying the distinctive properties of, salifiable bases. But it is now found, that it is always decomposed, when presented for combination with a salifiable base. Besides, it has not a sour taste, and is incapable of reddening vegetable blues.

Chloriodic acid, like hydrocyanic acid, suffers decomposition, whenever the attempt is made to combine it with a salifiable base. It does not redden vegetable blues, but destroys them. Its taste has not been ascertained. Perhaps it would have been more correct to have adopted Gay-Lussac's opinion respecting its nature, and excluded it from the list of acids.

Chlorocyanic acid is not known to combine with any salifiable base; but it reddens vegetable blues. It is certainly

an acid of very doubtful character. So that it appears that two out of the three acids, which are unable or not known to combine with salifiable bases, belong to the class of acids of irregular constitution, so called in this work. It is not improbable that further researches may make it necessary to strike out these combinations from the list of acids.

Property of reddening vegetable blues, not possessed by all acids.

As to the property of reddening vegetable blues, which is generally supposed to be distinctive of acids, it would appear that it is merely a property, very generally associated with the essential one of neutralizing salifiable bases. For this reason, it is convenient to take the indications of acidity from it; and this course can lead to no error, when the chemist is acquainted with those acids, which do not possess this property.

Having now considered the principal properties characteristic of the class of acids, and noticed those acids, which are of doubtful character; it is next proper to say something of the arrangement of these bodies, which has been adopted in this work.

French doctrine of combustion and acidification explained.

After the chemistry of the French school had overturned the doctrines, connected with the supposed existence of phlogiston or an inflammable principle; a fundamental doctrine of the new theory was, that oxygen is essential to the production of combustion and acidity. It was contended, that, in every case of combustion, oxygen combines with the burning body, and separates from its light and heat; and that, when a body is acidified, it combines with oxygen, and in no case with any other substance.

Found to be erroneous.

The reader has already been put in possession of a sufficient number of facts, to enable him to determine that the French doctrine of combustion and acidification was erroneous. This very evidently appears, when it is recollected that a plurality of supporters have been discovered, and that a number of acids are now known, into which oxygen does not enter as a constituent.

The new views respecting acidification, made a new classification of acids necessary.

The discovery of acids, into which oxygen does not enter as a constituent, having destroyed the exact analogy, previously observed between the acids, a new arrangement of them appeared to be absolutely necessary. A classification of them has been devised by Dr. Thomson; but it is too intricate to be of practical utility. The arrangement, which has been adopted in the present work, is founded upon the analogies in composition of the different acids.

A number of acids, which have not oxygen as a constituent, agree in containing hydrogen as a common principle. These acids are hydrochloric (muriatic) acid, hydriodic acid, hydrosulphuric acid (sulphuretted hydrogen), hydro-

fluoric (fluoric) acid and hydrocyanic acid. This striking fact of the uniform presence of hydrogen in a number of important acids, in which oxygen does not exist, suggested the expediency of erecting a classification of these bodies, founded upon the presence or absence of oxygen or hydrogen in them.

Classification adopted, founded upon the presence or absence of oxygen or hydrogen.

Upon the presence or absence of oxygen or hydrogen, four classes of acids may be founded:

I. Acids, in which oxygen is present, but not hydrogen.

II. Acids, in which hydrogen is present, but not oxygen.

III. Acids, in which neither oxygen nor hydrogen is present.

IV. Acids, in which oxygen and hydrogen are both present.

This, however, is not exactly the arrangement, which is adopted. Some of the acids, in which oxygen is present but not hydrogen, have bases, which are capable of forming acid compounds with hydrogen. This circumstance suggested the expediency of letting those acids stand in a class by themselves, whose bases form acid compounds, by combining with oxygen or hydrogen indifferently. By this measure, acids whose bases are the same, are made to stand together.

So that the arrangement, founded upon the presence or absence of oxygen or hydrogen, modified in the way just mentioned, gives rise to five classes:

I. Acids, whose bases form acid compounds with oxygen or hydrogen indifferently.

II. Acids, whose bases form acid compounds with oxygen only.

III. Acids, whose bases form acid compounds with hydrogen only.

IV. Acids in which neither oxygen nor hydrogen is present.

V. Acids, in which oxygen and hydrogen are both present.

These classes, except the fourth, exhibit exactly the arrangement adopted. The fourth class, in the arrangement pursued, has the title of acids of irregular constitution. The acids which stand here cannot, indeed, be called acids, which contain neither oxygen nor hydrogen, although this is the case with some of them; so that, in this particular, the classification, founded upon the presence or absence of oxygen or hydrogen, has not been adhered to.

The object of the classification, which has been adopted, is to afford a key to the memory for recollecting the constituents of the different acids, by exhibiting their chemical relations to oxygen and hydrogen. With reference to the

Theory of acidification, which led to the classification adopted.

production of acidity, it would appear that chemical bodies arrange themselves in two sets; bodies called the bases of acids on the one hand, and oxygen and hydrogen on the other. The concurrence of one body, at least, from each of these sets, appears to be absolutely essential to the production of acidity. That this necessity of concurrence is not imaginary, but real, is evinced by this fact, that the bodies of neither set can produce acids by combinations among themselves.* Hence it is, that no acids, except those of doubtful character, are destitute of both oxygen and hydrogen.

Advantages of the arrangement.

By the first class of acids, the fact is clearly shewn, that chlorine, iodine, sulphur, selenium and tellurium are acidifiable by combining with either oxygen or hydrogen. The second class contains those acids, whose bases are acidifiable by oxygen only. These acids agree exactly in chemical constitution, and stand very well together. The third class contains the hydrofluoric (fluoric) acid and the hydrocyanic acid. The former has an undecompounded base, the latter, a compound base. Both these bases may be considered as acidified by hydrogen. The fourth class appears to contain a very proper association of acids. They are called acids of irregular constitution; and they are certainly irregular, with reference to any theory. Acids of the fifth class are those in which oxygen and hydrogen are both present. They are all, except the two first, triple compounds of carbon, hydrogen and oxygen. In any arrangement of acids, they would necessarily stand by themselves.

CHAPTER IV.

OF SALTS.

Salts are compounds formed between acids and salifiable bases.

Having finished the consideration of acids and given some account of their arrangement, the compound bodies, next to be considered, are those which are formed by the union of acids and salifiable bases. These combinations are called, by the chemist, salts.

The salts will be treated of in as many classes as there are salifiable bases; those formed by each base constituting the subject of a separate section.

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* Some of the compounds, included under the class of acids of irregular constitution, are exceptions to this statement; but their composition is so imperfectly ascertained, that it is not unlikely that they may hereafter prove to contain oxygen or hydrogen.

SECTION I.

SALTS OF AMMONIA.

SALTS OF AMMONIA are combinations of acids with the salifiable base ammonia. The most important of these salts are the following. Salts of ammonia; what compounds.

I. *Chlorate of Ammonia.*—Formerly called *Hyperoxymuriate of Ammonia.*—This salt was first formed by Chenevix. It may be prepared by dissolving carbonate of ammonia in chloric acid. The acid combines with the ammonia, and carbonic acid is extricated. It is in the form of crystals of an exceedingly sharp taste. It is soluble in water. When thrown upon a burning coal, it detonates with a red flame. It is decomposed by heat; chlorine, azote and oxygen being evolved, and hydrochlorate of ammonia (sal ammoniac), left behind. Chlorate of ammonia.

II. HYDROCHLORATE OF AMMONIA.

Usual chemical name, *Muriate of Ammonia.*—Common name, *Sal Ammoniac.*

1. Hydrochlorate of ammonia may be formed either by direct combination, or by decomposing sulphate of ammonia by chloride of sodium (common salt). Hydrochlorate, how obtained.

2. Originally this salt was procured, in Egypt, from the soot of camels' dung, by sublimation. It is now made in great abundance in Europe by the direct union of its constituents, or by the decomposition of the hydrochlorates (muriates).

3. Hydrochlorate of ammonia is sometimes found native, especially in the neighbourhood of volcanoes. It has been known for several centuries. Its composition, however, does not appear to have been ascertained until the beginning of the last, when it was pointed out by Geoffroy, Junior.

4. In commerce, this salt occurs generally in the form of firm, round, elastic, concavo-convex cakes. But by solution and crystallization it may be obtained in crystals. It has a pungent, urinous taste, and, in the compact cake, is not altered by exposure to air. Its specific gravity is 1·450. It is soluble, when in the cake, in somewhat more than three times its weight of cold water, and in its own weight of boiling water. In crystals, it requires less water for its solution. When heated, it sublimes unaltered, emitting a peculiar odour. Properties.

5. Hydrochlorate of ammonia, has the property of forming a permanent compound with perchloride of mercury (corrosive sublimate). This compound was called by the Combined with perchloride of mercury.

alchemists sal alembroth, and is usually called by chemists a muriate of mercury-and-ammonia, under an idea that it is a triple salt. According to the new chemical views respecting the nature of oxymuriatic acid (chlorine), it cannot be considered as a salt. When a solution of carbonate of potash or of soda is added to a solution of this compound, there falls a precipitate, which is the ammoniated perchloride of mercury, noticed under the head of the perchloride, page 106.

Composition.

6. Hydrochlorate of ammonia is composed of

Hydrochloric acid	37—one atom.
Ammonia	17—one atom.

Giving 54 for the number representing the weight of its atom.

Medical properties.

7. This salt was formerly used in medicine as an aperient and attenuant; but, at the present day, it is never given internally. Externally, it is used in solution for the purpose of removing chronic inflammation, and as a discutient in indolent tumours. It appears to act at first by the cold which it produces, and afterwards, as a stimulant, by creating a new and more healthy action.

III. *Iodate of Ammonia.*—This salt may be formed by saturating iodic acid with ammonia. It is in the form of crystals, which detonate when thrown upon heated coals, emitting a weak violet light and giving out vapours of iodine.

IV. *Hydriodate of Ammonia.*—This salt may be formed by mixing together equal volumes of hydriodic acid gas and ammoniacal gas; or by dissolving liquid ammonia in a solution of hydriodic acid. It is in the form of crystals, which are soluble in water and deliquescent in the air.

V. SULPHATE OF AMMONIA.

Secret Sal Ammoniac of Glauber.—*Vitriolated Ammoniac.*

Sulphate of ammonia; preparation.

1. This salt may be prepared by saturating ammonia with sulphuric acid, or by decomposing hydrochlorate of ammonia by means of the same acid. It has a sharp bitter taste. It is soluble in twice its weight of cold water, and in its own weight of boiling water. In the air, it slowly attracts moisture.

How obtained by the manufacturer.

2. It is formed by manufacturers from the impure liquid sub-carbonate of ammonia, obtained by distilling bones and other animal substances, by saturating it with sulphuric acid; or more economically, by double decomposition between it and sulphate of lime (gypsum). It is procured by them to be employed afterwards in the manufacture of hydrochlorate of ammonia (sal ammoniac), by double decomposition with chloride of sodium (common salt).

VI. *Sulphite of Ammonia.*—The taste of this salt is cooling and penetrating, and leaves a sulphureous impression in the mouth. It dissolves in its own weight of cold water, with the production of cold. Exposed to the air, it attracts moisture and is converted into a sulphate.

VII. HYDROSULPHATE OF AMMONIA.

Usual chemical name *Hydrosulphuret of Ammonia.*

1. This salt may be obtained perfectly pure by causing hydrosulphuric acid gas and ammoniacal gas to pass into a bottle surrounded with ice. It is in the form of transparent and colourless crystals. It is very volatile, and when kept in a bottle sublimes gradually to the top. Hydrosulphate of ammonia; how obtained.

2. For medical employment, it may be formed by passing a current of hydrosulphuric acid gas, through liquid ammonia. The solution of the salt, which is thus formed, is of a greenish-yellow colour.

3. This salt was first used in medicine by Cruickshank. It acts very powerfully upon the living system, inducing vertigo, drowsiness, nausea and vomiting, and lessening the action of the heart and arteries. It has been used, in solution, in diabetes by Dr. Rollo and others, in doses of from five to ten drops twice or thrice a day. Its activity entitles it to the notice of practitioners. Its action on the human system.

VIII. *Hydrosulphite of Ammonia.*—Usual chemical name *Hydroguretted Sulphuret of Ammonia.*—This salt may be obtained by pouring hydrosulphate of ammonia upon sulphur. The *fuming liquor of Boyle* is a hydrosulphite of ammonia with excess of base. This liquor may be prepared by distilling a mixture of equal parts of hydrochlorate of ammonia, sulphur and lime. It is a liquid of a deep-orange colour, which constantly emits white fumes of a strong ammoniacal and fetid odour, owing to the excess of its base. When allowed to stand, it gives off this excess, whereby its fuming property is destroyed, and deposites a portion of sulphur, sufficient to reduce its acid to the state of hydrosulphuric acid. In this way, it becomes converted into a hydrosulphate of ammonia. Hydrosulphite.

IX. *Nitrate of Ammonia.*—Old names, *Nitrum Semivolatile; Nitrum Flammans.*—This salt may be prepared by dissolving carbonate of ammonia in dilute nitric acid, and allowing the solution to stand until crystals form. These crystals constitute the salt in question. It has a very acrid, bitter, disagreeable taste. It is soluble in twice its weight of cold water, and in half its weight of boiling water. When exposed to the air, it attracts moisture, and deliquesces. When subjected to a heat, not exceeding 500°, it is wholly Nitrate.

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converted into protoxide of azote (nitrous oxide) and water. It is from this salt, that this protoxide is usually obtained. When exposed to a heat above 600°, it is totally decomposed, and converted into deutoxide of azote (nitrous gas), nitrous acid, water and azote.

X. CARBONATE OF AMMONIA.

(Formerly called, *Prepared Ammonia.—Mild Volatile Alkali.*)

Carbonate of ammonia.

1. This salt may be prepared by subliming a mixture of two parts of pure carbonate of lime (chalk) and one part of hydrochlorate of ammonia (sal ammoniac) both in powder, and made as dry as possible. The sublimed product is carbonate of ammonia.

Preparation of the impure carbonate by the manufacturer.

2. Carbonate of ammonia is obtained, by the manufacturer, by the destructive distillation of animal substances, which contain azote. The substances generally employed are refuse bones and horns. The distilled products are water, subcarbonate of ammonia and empyreumatic oil. Water is first driven over; then the subcarbonate, which dissolves in the water to the point of saturation and afterwards concretes in the upper parts and sides of the receiver, and lastly the oil. These three products are respectively called the *volatile liquor*, *salt* and *oil of hartshorn*. The volatile liquor and the salt contain a portion of the oil, which adheres obstinately, while the oil holds in solution a portion of the salt. None of these products, except the water, pre-exist in the distilled substance; they are all formed, during the process, by a new arrangement of its ultimate constituents. Azote and hydrogen combine to form ammonia, carbon and oxygen, to form carbonic acid, and carbon, oxygen and hydrogen, to form oil.

The volatile liquor and salt of hartshorn are too impure for use in medicine. The carbonate of ammonia, which they contain, may be saturated with sulphuric acid; and the sulphate thus formed is employed in the manufacture of hydrochlorate of ammonia (sal ammoniac) by the agency of chloride of sodium (common salt), as already mentioned under the head of the sulphate. A hydrochlorate being thus obtained, it may be converted into a pure carbonate in the manner detailed in the first paragraph.

Properties.

3. Carbonate of ammonia is in the form of a white crystallized mass of a fibrous texture, having the smell and taste of pure ammonia, but much weaker. It is soluble in twice its weight of cold water. In boiling water, it is volatilized. Its specific gravity is 0·966.

Water of carbonate of ammo-

4. The solution of carbonate of ammonia is officinal, under the name of water of carbonate of ammonia. It is

prepared, by the British colleges, by distilling with water a mixture of hydrochlorate of ammonia (sal ammoniac) and carbonate of potash. A double decomposition takes place; the hydrochloric acid and potash combine, so as to form chloride of potassium and water, the former of which remains in the retort; while the carbonic acid and ammonia, in a state of combination, are distilled over dissolved in the water.

...nia used in medicine.

The carbonate of lime will not answer in the preparation of this solution, as it does not suffer decomposition, in contact with the hydrochlorate, below the heat of boiling water.

5. Carbonate of ammonia is composed of

Composition.

Carbonic acid	22—one atom.
Ammonia	17—one atom.

Giving 39 for the number representing the weight of its atom.

6. Carbonate of ammonia is a very important article of the materia medica. It is a powerful stimulant, and is particularly suited to the treatment of low fevers. Its average dose is about five grains, made up in pills, and given every two or three hours. It is very often combined with opium.

Medical properties.

When carbonate of ammonia is exposed to the air, it loses part of its base, and is converted into a bicarbonate; but this salt is not of sufficient importance to be described. When long or insecurely kept, the carbonate loses a large proportion of its ammonia, on account of its volatile nature, and approaches to the state of bicarbonate. It is sometimes sold by the apothecaries containing but half its proper quantity of ammonia.

XI. *Phosphate of Ammonia.*—This salt may be prepared by saturating superphosphate of lime, obtained from bones, with ammonia. The ammonia combines with the excess of acid, and, by evaporation, crystals of phosphate of ammonia are obtained. Its taste is saline, and somewhat bitter. It is soluble in twice its weight of cold water. Its specific gravity is 1·8051. In the air, it undergoes no alteration. From the activity of its constituents, there is reason to believe that it might be employed as a powerful and diffusive stimulus.

Phosphate of ammonia.

XII. *Hydrofluate of Ammonia.*—Usual chemical name, *Fluate of Ammonia.*—This salt may be formed by saturating pure hydrofluoric acid with ammonia. In a liquid state, it is neutral; but when evaporated, part of the ammonia flies off. It does not crystallize. When exposed to heat, it dissipates in thick white vapours. It precipitates all the earthy salifiable bases, and all the alkaline, except potash and soda.

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XIII. *Chlorocarbonate of Ammonia.*—Chlorocarbonic acid neutralizes four times its volume of ammonia.

XIV. *Borofluate of Ammonia.*—Ammonia combines in three proportions with borofluoric acid.

XV. *Silicofluate of Ammonia* may be formed by mixing its constituents together in a gaseous state. It is composed of one volume of silicofluoric acid and two volumes of ammonia.

XVI. *Sulphocyanate of Ammonia* is a soluble uncrystallizable salt.

Ferrocyanate.

XVII. *Ferrocyanate of Ammonia.*—Formerly called, *Triple Prussiate of Ammonia; Prussiate of Ammonia-and-Iron.*—This is a very soluble, deliquescent, crystallizable salt of a light lemon-yellow colour.

Urate.

XVIII. *Urate of Ammonia.*—This salt is a white tasteless powder, very much resembling uric acid. It is a constituent in several species of urinary calculi. According to Fourcroy and Vauquelin, some of these concretions are composed entirely of this salt.

Purpurate.

XIX. *Purpurate of Ammonia.*—Dr. Prout first obtained this salt from the pink liquid, formed by the action of dilute nitric acid upon uric acid, which is a solution of this purpurate. This salt is in the form of transparent crystals, which appear of a deep garnet-red colour by transmitted light, but brilliant green by reflected light. It is soluble in 1500 parts of cold water, and in a much smaller quantity of boiling water. The solution has a beautiful rose-red colour and a sweetish taste, but no smell. Dr. Prout supposes that the pink sediment, deposited in the urine of persons labouring under fevers, consists chiefly of this salt.*

Oxalate.

XX. *Oxalate of Ammonia.*—This salt may be formed by saturating oxalic acid with ammonia, and evaporating the solution until crystals form. It has a bitter unpleasant taste, somewhat like that of hydrochlorate of ammonia (sal ammoniac). It is much used as a re-agent for the detection of lime, which it does by precipitating this alkaline base in the form of an insoluble oxalate of lime.

Succinate.

XXI. *Succinate of Ammonia.*—This salt has a sharp, bitter and cooling taste. When exposed to heat, it sublimes without decomposition. It precipitates peroxide of iron from all its solutions of a deep flesh-red colour. It likewise precipitates mercury. It throws down none of the alkaline or earthy salifiable bases, except barytes.

Acetate of ammonia,

XXII. *Acetate of Ammonia.*—This salt may be formed

* Phil. Trans. 1818. Part II. p. 420.

by saturating acetic acid with ammonia. It may be obtained in crystals by cautious evaporation. The crystals are long, slender and flatted, and of a pearl-white colour. Their taste is cooling and sweetish, somewhat like that of a mixture of sugar and nitrate of potash (nitre). They are very deliquescent. When dissolved in water, they form the medicinal preparation called water of acetate of ammonia.

CHAP. IV. dissolved in water, forms spirit of Mindererus.

WATER OF ACETATE OF AMMONIA.

(Commonly called, *Spirit of Mindererus.*)

1. This solution may be formed by saturating carbonate of ammonia with diluted acetic acid (distilled vinegar). It may be formed also, in a state of impregnation with carbonic acid, by adding diluted acetic acid to the carbonate contained in a phial, which must then be tightly corked. In this way, the carbonic acid, which would otherwise be extricated, is made to unite with the dissolved acetate, whereby the latter is rendered more pleasant as a medicine.

Preparation of the spirit.

2. The solution of acetate of ammonia is a very valuable medicine. It operates as a powerful sodorific, without quickening the circulation or increasing the heat of the body. In perturbed states of the stomach it acts very effectually in calming the irritation of this organ. It is more particularly suited to advanced stages of inflammatory fevers, where the skin remains obstinately dry. The medium dose is half an ounce.

Medical properties.

XXIII. *Tartrate of Ammonia.*—This salt has a cooling bitter taste, like that of nitrate of potash (nitre). It is very soluble in water.

XXIV. *Benzoate of Ammonia.*—This is a very soluble, difficultly crystallizable and deliquescent salt. It precipitates none of the salifiable bases from their solutions, except the oxides of iron, tellurium, mercury, and, perhaps, of copper: iron is thrown down of an orange colour, and the other metals, white. From this circumstance, it has been recommended as an excellent re-agent for the detection of iron.

XXV. *Citrate of Ammonia.*—This salt may be formed by dissolving carbonate of ammonia in citric acid. Its taste is cooling and moderately saline. It is not crystallizable, unless its solution be evaporated to the consistence of a thick syrup. An extemporaneous solution of this salt in water may be obtained by dissolving carbonate of ammonia in lemon juice. This solution, if swallowed during the extrication of the carbonic acid, forms a very excellent effervescing draught.

Citrate of ammonia.

Besides the salts of ammonia, already described, there have been more or less examined, the selenate, hydroselenate, tellurate, borate, phosphite, hypophosphite, arseniate,

List of salts of ammonia not described.

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arsenite, chromate, molybdate, tungstate, antimoniate, formate, sorbate, saclactate, mellate, camphorate, malate, lactate, moroxylate, suberate, sumate and boletate; but these salts are of too little importance to be described. The remaining salts of ammonia, amounting in number to 15, are unknown.

General properties of the salts of ammonia.

The salts of ammonia agree in the following particulars:

1. They are nearly all soluble in water.

2. They are decomposed by potash and lime, which cause them to emit an ammoniacal smell.

3. They are dissipated by the action of heat, unless they contain a fixed metallic acid; in which case such acid alone remains behind.

4. They are precipitated of an orange colour, by solutions of platinum.

SECTION II.

SALTS OF POTASH.

Salts of potash are what compounds.

Salts of Potash are combinations of the different acids with the salifiable base potash. The following are the most important of these compounds.

I. CHLORATE OF POTASH.

(Formerly called, *Hyperoxymuriate of Potash.*)

Chlorate of potash; how obtained.

1. This salt may be formed by saturating carbonate of potash, diluted with six times its weight of water, with chlorine gas. Crystals form in the solution, which consist of chlorate of potash. They may be purified by solution in boiling water and subsequent crystallization. This salt was discovered by Berthollet.

Properties.

2. Chlorate of potash has a cooling, austere and disagreeable taste. It is soluble in 16 parts of cold water, and in 2½ parts of boiling water. Its specific gravity is 1·989. When rubbed smartly, it emits a number of sparks. It is not altered by exposure to air. When heated to redness, it gives out one-third of its weight of very pure oxygen gas, and is converted into chloride of potassium (muriate of potash). It explodes violently with almost all combustible substances. When triturated, in a mortar, with one-third of its weight of sulphur, a violent explosion takes place. The same effect is produced, when a similar mixture is struck with a hammer on an anvil. The detonating property of this salt suggested its use to Berthollet as a substitute for nitre in the manufacture of gunpowder; but an accident, which occurred in the first experiment, and which occa-

Explodes with combustibles.

sioned the death of two persons, proved it too liable to explosion to be employed as a constituent of this compound. This salt detonates also with phosphorus, either by friction or percussion: but the quantities used of these substances must not exceed a grain, otherwise the explosions might be attended with injury. It likewise detonates, when treated in the same way, with most of the metals, and with sugar, gums, oils and alcohol. When triturated in a mortar with a piece of cotton cloth, small and repeated explosions are heard; and if the cloth be perfectly dry and a little warm, it sometimes takes fire. When nitric acid is poured upon a mixture of this salt and phosphorus, inflammation takes place, and flakes of fire are emitted, at intervals, for some time.

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Composition.

3. Chlorate of potash is composed of

Chloric acid	76—one atom.
Potash	48—one atom.

Giving 124 for the number representing the weight of its atom.

Employed in medicine.

4. A solution of the chlorate of potash, under the name of oxymuriatic alkaline water, is an officinal preparation of the Dublin college. It has been employed in the treatment of syphilis, under the influence of the theory that anti-venereal remedies are efficacious in consequence only of the oxygen which they contain. It has been used also in typhus and in scurvy as an oxidizing remedy. The trials which have been made with it, in these diseases, have not realized the expectations entertained of its powers.

Oxychlorate of potash; how obtained.

II. *Oxychlorate of Potash.—Perchlorate of Potash* of Thomson.—This salt is formed by treating a small quantity of chlorate of potash (50 grains) with three or four times its weight of strong sulphuric acid; an intense action takes place, and the whole assumes a yellow colour. After the first violent action is over, which is occasioned by the extrication of deutoxide of chlorine, apply heat to the mixture, until its yellow colour disappears, and let it stand to crystallize. The salt obtained is oxychlorate of potash, mixed with some bisulphate of potash. The bisulphate may be separated by dissolving the crystals, and submitting them to a second crystallization.

Properties.

This salt was first obtained by Count Von Stadion, who discovered it to be composed of a peculiar acid, previously unknown, united to potash. It has a weak taste. It is not altered by exposure to the air. It dissolves in 55 parts of cold water, and in a smaller quantity of boiling water. When triturated in a mortar with sulphur, it detonates feebly. When heated to the temperature of 412°, it is

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decomposed into chloride of potassium (muriate of potash) and oxygen gas. When mixed with its own weight of sulphuric acid, and exposed to a heat of 280°, in a retort, it is decomposed; sulphate of potash is formed, and its peculiar acid distils over.

No such salt as hydrochlorate of potash.

III. *Hydrochlorate of Potash* does not exist. When hydrochloric acid and potash come in contact, they mutually decompose each other. The hydrogen of the acid combines with the oxygen of the potash, forming water; while the chlorine of the former combines with the metallic radical of the latter, and forms chloride of potassium. This chloride is usually known by the name of muriate of potash.

Iodate of potash.

IV. *Iodate of Potash.*—This salt may be obtained by dissolving iodine in a solution of potash, and digesting the crystals thereby formed in alcohol, to dissolve away some hydriodate of potash, with which they are mixed. They then consist of pure iodate of potash. This salt is not altered by exposure to air. When heated to redness, it is decomposed, oxygen gas is evolved, and iodide of potassium remains behind.

Hydriodate.

V. *Hydriodate of Potash.*—This salt may be formed by dissolving carbonate of potash in hydriodic acid. An effervescence takes place, and a solution of the salt is obtained. It exists in solution only. Whenever the attempt is made to obtain it in crystals, it becomes decomposed, and crystals of iodide of potassium are formed.

VI. SULPHATE OF POTASH.

(Formerly called, *Vitriolated Tartar.—Vitriolated Vegetable Alkali.* Old names, *Sal de duobus.—Sal Polychrestus Glaseri*, &c.)

Sulphate of potash; how obtained.

1. This salt may be formed by saturating a diluted solution of potash with sulphuric acid, and exposing the liquid formed to slow evaporation, until crystals make their appearance.

Preparation for use in medicine.

2. For the purposes of medicine, this salt is not often prepared by the direct combination of its constituents. A sulphate of potash is very often formed in the residuum of various pharmaceutical processes; and may be obtained very economically. In the formation of the fuming nitrous acid, which is effected by the decomposition of nitrate of potash (nitre) by means of sulphuric acid, the residuum is a supersulphate of potash. By saturating this supersulphate with carbonate of potash, dissolving it in warm water, and crystallizing it, pure sulphate of potash may be obtained.

3. This salt may be obtained also by double decomposition from carbonate of potash (salt of tartar) and sulphate of iron (green vitriol). When the sulphate of iron in solu-

tion is added to a solution of carbonate of potash; a very pure carbonate of iron precipitates, while sulphate of potash remains in solution. In this way the operator may obtain two useful medicinal preparations in one chemical process. CHAP. IV.

4. It may be mentioned, that, in addition to these methods, sulphate of potash may be obtained from the residuum of the process laid down by the colleges for obtaining carbonate of magnesia (common magnesia). It is directed to decompose sulphate of magnesia (Epsom salt) by means of carbonate of potash. A carbonate of magnesia is precipitated, while a sulphate of potash remains in solution.

Sal polychrest; how formed:

5. When equal parts of nitre and flowers of sulphur are mixed together and deflagrated in a red-hot crucible, the resulting mass is a salt, which is called sulphate of potash with sulphur, or sal polychrest. As this salt, when examined, is not found to differ from sulphate of potash, this name cannot be correctly applied to it. The rationale of its formation would seem to be, that the sulphur, after being acidified at the expense of the decomposed acid of the nitrate, combines with the potash of this salt. Hence, sal polychrest may be considered as nearly synonymous with sulphate of potash.

the same as sulphate of potash.

Properties of sulphate of potash.

6. Sulphate of potash is in the form of small, transparent, very hard crystals. It has a disagreeable bitter taste. It dis solves in 16 times its weight of cold water, and in 5 times its weight of boiling water. Exposure to the air produces no alteration. It decrepitates when placed on burning coals.

Medical properties.

7. In medicine, it is used in small doses as an aperient; in large ones (four or five drachms) as a mild cathartic. Combined with ipecacuanha and opium, it forms the powder of ipecacuan and opium, formerly called Dover's powder.

Sulphite of potash.

VII. *Sulphite of Potash.—Sulphurous Salt of Stahl.*—This salt may be formed by passing sulphurous acid into a saturated solution of carbonate of potash, until all effervescence ceases. It is in the form of white transparent crystals. Its taste is penetrating and sulphureous. It is soluble in its own weight of cold water. When exposed to the air, it scarcely changes its appearance, and is gradually converted into sulphate of potash.

Hydrosulphate of potash.

VIII. *Hydrosulphate of Potash.*—Usual chemical name, *Hydrosulphuret of Potash.*—This salt may be formed by saturating potash with hydrosulphuric acid; or by dissolving sulphuret of potash in water. It is in the form of transparent colourless crystals, not unlike those of sulphate of soda (Glauber's salt). Its taste is alkaline and extremely bitter. In the air, it deliquesces into a syrupy liquid, and is converted into sulphate of potash. In the form of crys-

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tals, it has no smell; but, after having deliquesced, it emits a very fetid odour. It is decomposed by acids, hydrosulphuric acid being evolved with violent effervescence. It has been used internally as an antidote to metallic poisons and for the purpose of restraining excessive salivations, and in cutaneous affections. It has been used successfully for the cure of tenia capitis and psora. It was this salt which was recommended, in the treatise on croup, by one of the successful candidates for the prize proposed by Bonaparte for the best dissertation on this disease.

Medical uses.

Hydrosulphite.

IX. *Hydrosulphite of Potash.*—Usual chemical name, *Hydroguretted Sulphuret of Potash.*—This salt may be formed, to all appearance the same, by different processes, but differing somewhat in the quantity of sulphuretted hydrogen, which it may yield by means of acids. It may be formed by mixing together hydrate of potash and flowers of sulphur in a phial. It is also formed, when liquid potash is kept ten or twelve hours upon flowers of sulphur, or when sulphuret of potash is moistened with water. The formation of the salt depends upon the decomposition of water, and the consequent production of a portion of hydrosulphuric acid, which, combining with an additional portion of sulphur, becomes hydrosulphurous acid (hydroguretted sulphur) and, thus altered, unites with the potash. It is in the form of a liquid of a deep red colour. Sometimes it has no smell; at other times it exhales the smell of radishes, and after being kept, that of hydrosulphuric acid. Its taste is acrid, and, as it were, bitter and cooling. It attacks all metals with great energy, converting them generally to the state of sulphurets.

Hydrosulphates and hydrosulphites of alkaline bases, used as metallic precipitants; and especially the two last described salts.

The hydrosulphates and hydrosulphites of the alkaline salifiable bases have the property of precipitating all metallic solutions, except that of rhodium; some modification of the acids of these salts, falling down in combination with the metal present. Hence they become very valuable tests of metallic bodies; more especially as they do not precipitate any of the earthy salifiable bases, except alumina and zirconia; and these are thrown down in combination with the base of the hydrosulphate or hydrosulphite employed, hydrosulphuric acid (sulphuretted hydrogen) being at the same time evolved. As, in these precipitations, the two last described salts are generally preferred, a table of the precipitates produced by them is annexed.

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Table of their precipitations.

Metals.	*Precipitated by* Hydrosulphate of potash.	*Precipitated by* Hydrosulphite of potash.
Arsenic.	Yellow.	Yellow.
Chromium.	Green.	
Molybdenum.	Reddish-brown.	
Columbium.	Chocolate.	
Antimony.	Orange.	Orange-yellow.
Tellurium.	Black?	Deep-brown, or black.
Iron.	Black.	Black, becoming yellow.
Nickel.	Black.	Black.
Cobalt.	Black.	Black.
Manganese.	White.	White.
Cerium.	Brown.	
Uranium.	Brown.	
Zinc.	White.	White.
Lead.	Black.	White, becoming black.
Tin.	Black.	Black.
Copper.	Black.	Brown.
Bismuth.	Black.	Black.
Mercury.	Brown-black.	Brown, becoming black.
Silver.	Black.	Black.
Gold.	Black.	Black.
Platinum.	Black.	Black.
Palladium.	Black.	
Titanium.	Grass-green.	

By the above table, it is perceived that, in some cases, the metal in solution may be distinguished by the colour of the precipitate formed.

X. NITRATE OF POTASH.

(Common names, *Nitre.—Saltpetre.*)

Nitrate of potash; formed artificially in nitre beds.

1. The chemist is not under the necessity of forming this salt by direct combination. It is found native in different parts of the world, particularly in the East Indies, and in the United States. It is formed artificially, in France and Germany, in what are called nitre beds, which consist of putrefying animal and vegetable remains, mixed with some calcareous substance, and exposed to a dry atmosphere; a certain degree of heat is also necessary. It is extracted from these materials, when formed in sufficient quantities, by lixiviation and crystallization.

Manner of formation, not easily explained.

2. It is not easy to understand the manner in which this salt is formed in artificial nitre beds. Since the discovery of the constituents of nitric acid, it may not be difficult to account for the formation of the acid of the salt. It is generally supposed that azote, in the nascent form, extricated from the putrefying animal substances, combines with the oxygen of the air. The potash, perhaps, is derived from the vegetable part of the bed, and from the soil.

Properties.

3. Nitrate of potash is in the form of pretty large crys-

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tals, of a sharp, bitterish, cooling taste. It is soluble in seven times its weight of cold water, and in rather less than its own weight of boiling water. It is not altered by exposure to air. Its specific gravity is 1·933.

Effects of heat.

4. When this salt in solution is exposed to a boiling heat, it is in part evaporated along with the water. When subjected to a strong heat, it melts, and congeals upon cooling into an opaque mass. When heated to redness, it begins to disengage oxygen gas; and if the same heat be kept up for some time, about one-third of its weight of this gas may be obtained. Afterwards, if the heat be continued, azotic gas is evolved.

Detonates with combustibles.

5. When mixed with combustibles, it detonates violently. When thrown into a red-hot crucible with an equal quantity of charcoal, a detonation and most brilliant combustion take place. The charcoal becomes acidified, and at the same time the nitric acid is entirely decomposed; while the fixed product is carbonate of potash. The carbonate of potash, when thus formed, was formerly called *nitre fixed by charcoal*. When phosphorus is used instead of charcoal, a more violent detonation is produced. It is capable of oxidizing all the metals; not excepting gold or platinum.

Composition.

6. Nitrate of potash is composed of

Nitric acid	54—one atom.
Potash	48—one atom.

Giving 102 for the number representing the weight of its atom.

Uses of nitrate of potash.

7. Nitrate of potash has many uses in the arts. It is this salt, which furnishes all the nitric acid, which is manufactured. When burnt with bitartrate of potash (tartar), it furnishes a very pure carbonate of potash. It is very useful in the assaying of various ores, and in the analysis of many animal and vegetable substances. But by far its most important use is as a constituent in gunpowder. One hundred parts of this powder are composed of

A component part of gunpowder.

76	parts of nitrate of potash.
15	charcoal; and
9	sulphur.

Gunpowder; how formed.

In the formation of gunpowder, these ingredients are first separately reduced to a fine powder, then mixed intimately, and formed into a paste with water. After this paste has dried a little, it is forced through a kind of sieve. It is in this manner reduced to grains of a determinate size. The powder, when thus prepared, is dried, and then subjected to a rotary motion in barrels, which are turned on their axes. By this operation, the grains constantly rub against each other, and become in some degree polished. After

undergoing the process last mentioned, it is called glazed gunpowder.

Explodes in vacuo. The explosion of gunpowder in the open air is familiar to every one; but it has this same property, when heated, to the requisite point, even in a vacuum. The gaseous products of the combustion of gunpowder are carbonic acid gas, azotic gas, sulphurous acid gas, and probably hydrosulphuric acid gas, (sulphuretted hydrogen). The fixed products are potash combined with a small portion of carbonic acid, sulphate of potash, a small quantity of sulphuret of potash, and unconsumed charcoal. (Products of its explosion.)

Nitrate of potash is used in forming white and black flux. Nitrate of potash, deflagrated in a crucible with bitartrate of potash (tartar), forms white and black flux. When these salts are used in equal parts, the product of the deflagration is a mixture of carbonate of potash and pure potash, or white flux. When the proportions used are two parts of bitartrate of potash and one part of nitrate of potash, the product is a mixture of carbonate of potash and charcoal, or black flux. The charcoal in these processes is furnished by the decomposition of the tartaric acid.

It possesses important medicinal powers. 8. Nitrate of potash is very extensively employed in medicine. Its general operation is that of an antiphlogistic remedy. It diminishes the heat of the body and the fulness of the pulse. It increases the secretion of both sweat and urine, and acts upon the bowels so as to keep them in a soluble condition. Its use, however, cannot be long continued without danger of injuring the stomach. The usual dose is from ten to twenty grains, repeated every two or three hours during the day. In larger doses of an ounce, to which extent it has been taken on some occasions by mistake for sulphate of soda (Glauber's salt), it produces very alarming symptoms, such as vomiting and purging of blood, and convulsions, which sometimes terminate fatally.

Potash forms two salts with carbonic acid. Potash combines in two proportions with carbonic acid, and forms carbonate and bicarbonate of potash.

XI. CARBONATE OF POTASH.

Old names, *Fixed Nitre,—Salt of Tartar,—Mild Vegetable Alkali.*

1. Carbonate of potash; how obtained. 1. This salt may be obtained by incinerating bitartrate of potash (tartar). In this operation, the tartaric acid of the bitartrate is wholly decomposed, and the carbonic acid, formed during its decomposition, combines with its potash. When obtained by this process, it was formerly called salt of tartar.

2. It may be obtained also, tolerably pure, by exposing impure carbonate of potash (the pearl ash of commerce) to

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a low red heat, in order to burn off the combustible impurities, and afterwards, by mixing the mass obtained with an equal weight of water, allowing the dregs to subside, decanting the pure liquor, and evaporating it to dryness in an iron vessel.

How obtained in the large way.

3. Carbonate of potash, in the large way and for the purposes of commerce, is prepared by lixiviating the ashes of vegetables, in barrels, first with cold water, and afterwards with hot. The liquor formed, after being filtered, is evaporated to dryness in an iron pot. The dry mass thus obtained is called potashes, and has a brown or black colour, owing to the presence of some vegetable matters. To get rid of these matters, the potashes are exposed to heat, in a reverberatory furnace, whereby every thing combustible is dissipated, and the mass, made to assume a light grey colour. In this stage of its purification, carbonate of potash is called pearl ash.

Carbonate of commerce contains impurities.

Carbonate of potash of commerce, besides the pure carbonate, contains the sulphates of potash and lime, and chloride of potassium (muriate of potash.)

4. Impure carbonate of potash (potashes of commerce) is prepared, in the largest quantities, in the United States and in Canada, and on the shores of the Baltic; in which parts of the world, immense forests furnish inexhaustible materials for the formation of this important substance.

Chemical nature of carbonate of potash remained a long time unknown.

5. Carbonate of potash was long considered to be a simple substance. Its causticity, produced when treated with lime, was not suspected to depend upon a decomposition. Meyer of Germany explained this circumstance by supposing that there became combined with common potash, when converted to the caustic state, a certain acid, which was separated, whenever it lost its causticity. This same theory, he applied to lime. It was reserved, however, for Black to give the true explanation of the difference between caustic and mild potash, in consequence of his discovery of carbonic acid.

Its proximate constituents discovered by Black.

This chemist ascertained, that, when common potash is made caustic by lime, the carbonic acid of the former is transferred to the latter, which thereby becomes carbonate of lime (chalk); and that common potash, deprived of its carbonic acid, becomes caustic potash. Black, therefore, may be considered as the discoverer of the proximate constituents of carbonate of potash.

Properties of carbonate of potash.

6. Carbonate of potash has a strong alkaline taste, and acts with considerable energy upon animal and vegetable substances. When exposed to the air, it deliquesces and assumes the consistency of an oil. It does not absorb carbonic acid from the atmosphere.

7. The solution of the carbonate of potash is an officinal preparation. When obtained by exposing the carbonate to the atmosphere, in a moist place, it was formerly called *oleum tartari per deliquium* (oil of tartar by deliquescence). It is in this way that it is prepared by the London college, under the name of water of prepared kali. The Dublin college form the solution by dissolving the common carbonate of potash in an equal weight of water, and call it *mild ley*. It would be preferable to form it by dissolving the crystallized carbonate in a determinate quantity of water.

Its solution, an officinal preparation.

8. Carbonate of potash is composed of

Composition.

Carbonic acid	22—one atom.
Potash	48—one atom.

Giving 70 for the number representing the weight of its atom.

9. Carbonate of potash is frequently used in medicine. It is a very powerful diuretic, and has considerable influence over the hepatic system. It is very much employed in the formation of effervescing mixtures, which consist of the carbonate, dissolved in some diluted acid. For this purpose, vinegar, cyder, or lemon juice may be employed. These acid liquors displace the carbonic acid, creating the effervescence, during which the medicine must be swallowed. The principal intention of these mixtures is to calm irritation of the stomach.

Medical properties.

XII. BICARBONATE OF POTASH.

1. This salt may be formed by passing carbonic acid through a solution of carbonate of potash, until it refuses to absorb any more; or by distilling the carbonate of potash with carbonate of ammonia. In this process the carbonate of potash always lets fall a portion of silica. This salt is not deliquescent like the carbonate, but remains unaltered in the air. Its taste is alkaline, but not caustic. It dissolves in four times its weight of cold water, and in a much smaller quantity of hot water. Heat deprives it of water and a part of its acid, but does not decompose it entirely.

2. Bicarbonate of potash; how obtained.

2. Bicarbonate of potash is composed of

Composition.

Carbonic acid	44—two atoms.
Potash	48—one atom.

Giving 92 for the number representing the weight of its atom.

3. This salt in solution constitutes the solution of the super-carbonate of potash of the Edinburgh college. For internal use, it is a much preferable preparation of potash, to the deliquesced or dissolved carbonate; being much more

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pleasant to the taste, and less apt to offend the stomach. It is, in fact, the only preparation of potash, which can be given in large doses conveniently, for any length of time, in calculous cases. When diluted to the degree directed by the Edinburgh college, it may be taken to the extent of six or eight ounces, two or three times a day.

Potash forms two salts with arsenic acid.

Potash combines in two proportions with arsenic acid, and forms arseniate and binarseniate of potash.

1. Arseniate of potash.

XIII. *Arseniate of Potash* may be obtained by saturating carbonate of potash with arsenic acid. It is an uncrystallizable deliquescent salt. It is not used in medicine.

XIV. BINARSENIATE OF POTASH.

Arsenical Neutral Salt of Macquer.

2. Binarseniate.

1. Binarseniate of potash may be formed by distilling, in a retort, equal parts of nitrate of potash (nitre) and arsenious acid. A saline mass is obtained, which, upon solution in hot water and proper evaporation, yields transparent crystals of this salt.

2. This salt is soluble in water, and gives a red colour to vegetable blues. It is permanent in the atmosphere. It is sometimes used in medicine.

XV. ARSENITE OF POTASH.

Arsenite of potash; how obtained.

1. Arsenite of potash may be formed by saturating a solution of carbonate of potash with arsenious acid (white oxide of arsenic). It is in the form of a yellow viscid liquid, which does not crystallize.

Diluted with water, forms Fowler's solution.

2. This salt, when largely diluted with water, constitutes the celebrated arsenical solution of Fowler.

[1] This solution is formed by boiling sixty-four grains of arsenious acid with an equal quantity of carbonate of potash, until the former is entirely dissolved, and adding so much pure water as will increase the solution to one pound.

Arsenic generally given, as a medicine, in this form.

[2] It is in the form of Fowler's solution that arsenic is most commonly exhibited. It is not easy to explain, in general terms, the operation of this solution upon the living system, or that of any of the preparations of arsenic, when given as medicines. It is very often prescribed in intermittent fever, over which disease it exerts a very powerful influence. In hectic fever, it has been used, on many occasions, with temporary advantage, but not perhaps with lasting benefit. The medicine, when used too long or in too large doses, is very apt to produce anasarcous swellings, the appearance of which is the signal for its discontinuance.

The dose of the solution of arsenite of potash (Fowler's

solution) is from two to twelve drops, twice or thrice a day, according to the age and other circumstances of the patient. It is a good rule, however, always to begin with small doses, and afterwards if necessary to increase them. CHAP. IV.

XVI. *Hydrofluate of Potash.*—Usual chemical name, *Fluate of Potash.*—This salt may be formed by pouring a solution of potash into hydrofluoric acid. A combination takes place with the evolution of much heat. This salt has a very sharp taste; and is difficultly crystallizable, deliquescent and soluble. When exposed to heat, it first undergoes the aqueous and then the igneous fusion. Hydrofluate of potash.

XVII. *Silicofluate of Potash.*—*Fluosilicate of Potash* of Dr. Thomson.—This salt may be formed by dropping into a solution of silicofluoric acid, a solution of carbonate of potash. When first precipitated it is gelatinous, but when dried it becomes white like chalk. It has an acid taste. It is soluble in about 150 parts of boiling water; and it partly precipitates as the water cools. When strongly heated, it loses its acid, and melts into a glass. Silicofluate.

XVIII. *Sulphocyanate of Potash.*—This is a deliquescent salt, which is capable, according to Porrett, of uniting with cyanodide of mercury, and forming a compound in the form of crystals of a beautiful silvery lustre. Sulphocyanate.

XIX. FERROCYANATE OF POTASH.

Usual chemical names, *Prussiate of Potash-and-Iron—Triple Prussiate of Potash.*—Old names, *Prussian Alkali—Phlogisticated Alkali.*

1. This salt may be formed by the following process: Dissolve potash, quite pure, in six times its weight of water, and place it in a glass vessel in a sand bath, exposed to a heat of 170° or 180°. To this solution, add perferrocyanate of iron (Prussian blue) in powder, as long as this salt becomes grey by the action of the potash. Then increase the heat to 212°, and keep it at this point for half an hour. Filter the liquid, thus obtained, and saturate it with sulphuric acid, moderately diluted. The precipitate thereby formed must then be separated by the filter. Now evaporate the filtered liquor to one-fourth, and set it by to crystallize. In a few days, a number of crystals will be deposited, some of which will be of a yellow colour. Pick out these from the rest, which consist of sulphate of potash, and dissolve them in four times their weight of cold water, and re-crystallize. The crystals thus obtained will be pure ferrocyanate of potash. Ferrocyanate of potash; how obtained.

2. This salt, when pure, is in the form of transparent crystals of a pale yellow colour. In order to be perfectly

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preserved, it should be kept, in alcohol, in a well stopped vial.

Very much employed as a test for metals.

3. This salt is by far the most useful test of metallic substances known. It throws down almost all the metals from their solutions, and from the amount and colour of the precipitate, the particular metal in solution, and its proportion may in many cases be ascertained. From its great utility as a re-agent, it becomes of the utmost importance to the chemist that it should be prepared perfectly pure. For this reason, several distinguished chemists have investigated every cause of impurity, and given rules and cautions for its preparation.

Table of precipitations by this salt.

4. The following table exhibits the colours, as far as they have been ascertained, in which the different metals are precipitated from their solutions by means of this salt.

Chromium	Green.	Lead	White.
Columbium	Olive.	Tin	White.
Iron	Blue.	Peroxide of copper	White.
Nickel	Milk-white.	Protoxide of copper	Reddish-brown.
Cobalt	Grass-green.	Bismuth	White.
Manganese	Peach blossom.	Silver	White becoming blue.
Cerium	White.	Palladium	Olive.
Uranium	Brownish-red like blood.	Iridium	Becomes colourless.
		Titanium	Yellowish-brown.
Zinc	White.		

Composition.

5. According to an analysis by Porrett,* ferrocyanate of potash, deprived of water, is composed of

Ferrocyanic acid	68·6—
Potash	48·0—one atom.
	116·6

The reader is now enabled to perceive how well the chemical constitution, assigned to the ferrocyanic acid by Porrett, accords with the weight for it, as deduced from this salt.

Potash forms three salts with oxalic acid; one only noticed.

Oxalic acid combines in three proportions with potash, and forms oxalate, binoxalate and quadroxalate of potash; the binoxalate only will be noticed.

Binoxalate.

XX. *Binoxalate of Potash.*—Common names, *Salt of Wood-sorrel; Essential Salt of Lemons.*—This salt exists ready formed in the wood-sorrel (oxalis acetosella). It may be formed by direct combination, by dropping a solution of carbonate of potash into a saturated solution of oxalic acid. As soon as the proper quantity of potash is added, this salt precipitates. It is in the form of crystals, of a sharp, pungent, bitterish taste. It is soluble in about ten times its weight of

* Annals of Philosophy, XII. 214. (Sept. 1818.)

boiling water. It is not altered by exposure to air. It is very much employed to remove stains from linen.

XXI. ACETATE OF POTASH.

Old names, *Diuretic Salt.—Digestive Salt of Sylvius.*

Acetate of potash; how obtained.

1. Acetate of potash may be formed by dissolving carbonate of potash in diluted acetic acid (distilled vinegar). By evaporating cautiously the solution formed, crystals of acetate of potash will be deposited. It has a fine white colour, and sharp warm taste. It is soluble in about its own weight of water. When exposed to the air, it becomes somewhat moist, but suffers no other alteration.

Its medical properties.

2. Acetate of potash, when used as a medicine, acts as a gentle cathartic; but it may be so managed, as to prove powerfully diuretic. The dose varies from half a scruple to one or two drachms. When vinegar is poured upon carbonate of potash, a liquid acetate is readily formed, not inferior perhaps, for medical employment, to the crystallized salt.

Potash forms two salts with tartaric acid.

Potash combines with tartaric acid in two proportions, forming tartrate and bitartrate of potash. The bitartrate will be first described.

XXII. BITARTRATE OF POTASH.

Supertartrite of Potash of the Edinburgh College.
Tartar, when impure.—*Crystals of Tartar* and *Cream of Tartar*, when purified by solution and crystallization.

1. Bitartrate of potash; how obtained.

1. This salt may be obtained by dissolving impure bitartrate of potash (tartar) in hot water, and filtering the solution, while hot, to get rid of the earthy impurities. The filtered liquor, upon cooling, deposites crystals of bitartrate of potash, rendered impure by oily and colouring matters. It may be separated from these impurities, by being boiled with white clay. At Venice the solution of tartar is purified by means of whites of eggs and ashes, which precipitate the foreign matters.

Tartar exists in wines; and deposites on the inside of wine casks.

2. Tartar exists in new made wines, especially in the deepest coloured and coarsest kinds, and deposites itself on the sides of casks, in which these wines are kept. Before every vintage, when the casks, which had been used the previous year, are prepared to receive the new wine, it is scraped from their interior surfaces, and forms, according to its colour, white or red tartar. The methods by which it is purified have just been detailed.

Bitartrate described.

3. Bitartrate of potash is in the form of irregular imperfect crystals, very brittle and easily reduced to powder. It has an acid and rather unpleasant taste. Its specific gravity

is 1·953. It is soluble in about sixty parts of cold water, and in fourteen parts of boiling water. It is not altered by exposure to air; but when allowed to remain some time in solution, it is gradually decomposed, a mucous matter is precipitated, and their remains in solution, carbonate of potash coloured by a little oil. When exposed to heat, it melts, swells, blackens, and is entirely decomposed. When subjected to distillation, it yields, besides carbonic acid, bihydroguret of carbon and some oil, and an acid liquor consisting of the pyrotartaric acid, already described.

The bitartrate of potash of commerce (tartar) is never pure, as has been already mentioned. It generally contains between 5 and 6 per cent. of tartrate of lime.

Composition. 4. Bitartrate of potash is composed of

Tartaric acid	134	—two atoms.
Potash	48	—one atom.

Giving 182 for the number representing the weight of its atom.

Medical properties. 5. The properties of this salt, as a medicine, are those of a mild and cooling laxative. When properly managed, it is a very good diuretic also; and, with a view to this effect, it is often given, conjoined with jalap, in dropsy. In the dose of from half an ounce to an ounce, it is a gentle but effectual purgative. It is given in smaller doses, when its diuretic operation is desired.

XXIII. TARTRATE OF POTASH.

(*Tartrite of Potash* of the Edinburgh College.—Common names, *Soluble Tartar.*—*Tartarized Vegetable Alkali.*)

2. Tartrate of potash; how prepared. 1. This salt is easily prepared by adding bitartrate of potash (cream of tartar) to a hot solution of carbonate of potash, as long as any effervescence takes place. Part of the carbonate is thereby decomposed, and its potash combines with half the tartaric acid which exists in the bitartrate. The effervescence arises from the displaced carbonic acid. The mixture, thus formed, must then be boiled for some time, and afterwards evaporated until a pellicle forms on its surface. It is then set aside, and the crystals, which form during its cooling, are tartrate of potash.

Properties. 2. This salt has an unpleasant bitter taste. Its specific gravity is 1·55. It is soluble in its own weight of cold water, and in a much smaller quantity of boiling water. It is from its great solubility, when compared with bitartrate of potash (cream of tartar), that it takes its common name of soluble tartar. When exposed to heat, it melts, blackens and is decomposed.

3. Tartrate of potash is composed of

Tartaric acid	67—one atom.	
Potash	48—one atom.	

Composition.

Giving 115 for the number representing the weight of its atom. Hence it is obvious, that this salt differs from the bitartrate in containing an atom less of acid; or, which is the same thing, in being a combination of half as much acid with the same quantity of potash.

Medical uses.

4. Tartrate of potash, when used as a medicine, acts as a cathartic. In doses of from a scruple to a drachm, it acts as a mild cooling aperient. When taken to the amount of an ounce, it operates as a pretty strong purge. It is not, however, nearly so much used as many other saline purgatives.

Citrate of potash.

XXIV. *Citrate of Potash.*—This salt may be formed by dissolving carbonate of potash in citric acid, and evaporating the solution formed to a proper consistency. It is a very soluble, difficultly crystallizable and deliquescent salt. When obtained in the liquid form, by dissolving carbonate of potash in diluted lemon juice, it forms a very pleasant effervescing mixture, well suited for the purpose of allaying sickness of stomach, and stopping vomiting.

Pyrotartrate.

XXV. *Pyrotartrate of Potash*, with excess of acid, is a very different salt from bitartrate of potash. When in a neutral state, it precipitates the salts of zinc and barytes, which sufficiently distinguishes it from tartrate of potash.

List of salts of potash, not described.

Of the remaining salts of potash, the ammonio-sulphate, selenate, tellurate, nitrite, borate, phosphate, hypophosphite, chromate, molybdate, tungstate, nitro-tungstate, columbate, antimoniate, antimonite, urate, purpurate, sorbate, succinate, benzoate, saclactate, mellate, camphorate, malate, lactate, suberate, zumate and boletate are more or less known to chemists; but as they have no particular interest for the student of medicine, their description is omitted in this work. The rest of the salts of potash, amounting to 16, are unknown.

General properties of the salts of potash.

The properties, characteristic of the salts of potash, are the following.

1. They are all, with very few exceptions, soluble in water, but less so than the salts of ammonia.

2. When a solution of tartaric acid is added to their solutions in water, a precipitate of bitartrate of potash (cream of tartar) takes place.

3. When a solution of sulphate of alumina is dropped into their solutions, crystals of sulphate of alumina-and-potash (one species of alum) become formed.

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4. They are not volatilized, when exposed to a red heat, as is the case with the salts of ammonia. When they contain a combustible acid, such acid is decomposed, and the residue, after the heat is withdrawn, is carbonate of potash, mixed with a little charcoal. When their acid is not combustible, they fuse without suffering decomposition. To this, however, there are several exceptions; the acid of the nitrate is decomposed at a red heat; and, at the same temperature, the sulphite becomes a sulphate, sulphur being sublimed.

5. They let fall an orange-coloured precipitate, when treated with a solution of platinum.

SECTION III.

SALTS OF SODA.

Salts of soda; what compounds.

SALTS OF SODA are compounds of the different acids with the salifiable base soda. The following are the most important of these salts.

Chlorate of soda.

I. *Chlorate of Soda.*—Former chemical name, *Hyperoxymuriate of Soda.*—This salt may be formed by dissolving carbonate of soda in chloric acid; or by passing a current of chlorine through a solution of the same salt. It is in the form of crystals, of a sharp, cooling taste. When placed on burning coals, it melts into globules, and produces a yellow light.

No hydrochlorate of soda.

II. *Hydrochlorate of Soda* does not exist. When the attempt is made to combine hydrochloric acid with soda, a double decomposition takes place; the hydrogen of the acid combines with the oxygen of the soda and forms water, while the chlorine of the former and the sodium of the latter unite and form a chloride. This chloride (common salt) was formerly supposed to be a muriate (hydrochlorate) of soda. It has already been described in a preceding part of this work.

III. *Iodate of Soda.*—This salt may be formed by dissolving iodine in a solution of soda. It is in the form of crystals, soluble in about 14 times their weight of cold water. When heated sufficiently, it gives out 24½ per cent. of oxygen gas, and is converted into iodide of sodium.

IV. *Hydriodate of Soda.*—This salt may be formed by dissolving carbonate of soda in hydriodic acid. It is in the form of large deliquescent crystals, which contain a good deal of water of crystallization.

V. SULPHATE OF SODA.

(Common names, *Glauber's Salt.—Vitriolated Natron.—Vitriolated Fossil Alkali.*)

1. This salt may be formed by saturating carbonate of soda with sulphuric acid. Sulphate of soda.

2. It is obtained by the manufacturer, most generally, from the residuum of the process for obtaining hydrochlorate (muriate) of ammonia, by the mutual action of sulphate of ammonia and chloride of sodium (common salt). It may be obtained, economically, by making into a paste with a sufficient quantity of water, eight parts of burnt sulphate of lime (gypsum), five parts of clay, and five parts of chloride of sodium (common salt). This mixture is burnt in a kiln or oven, then ground to powder, and afterwards treated with water, and evaporated until crystals of sulphate of soda form. How prepared in the large way.

3. This salt has been found native, in large quantities, in Persia, Bohemia and Switzerland.

4. Sulphate of soda is in the form of crystals, possessing a taste at first salt, but becoming afterwards nauseous and bitter. It is soluble in 2·86 parts of cold water, and in 0·8 parts of boiling water. When heated to redness and thus deprived of its water of crystallization, it requires 3·3 parts of water, at the temperature of 144°, for its solution. When exposed to the air, it falls into a white powder, and loses about half its weight in water of crystallization. When subjected to a heat gradually increased, it first undergoes the aqueous and afterwards the igneous fusion. Properties.

5. This salt, when anhydrous,* is composed of Composition.

Sulphuric acid	40—one atom.
Soda	32—one atom.

Giving 72 for the number representing the weight of its atom.

6. This salt is by far the most commonly used of the saline purgatives. When taken in a dose of from half an ounce to an ounce or more, it is a mild, but effectual cathartic. When given in smaller doses, largely diluted, it acts as an aperient and diuretic. When in a state of efflorescence, the dose should be reduced to one-half. Medical properties.

VI. *Hydrosulphate of Soda.*—Usual chemical name, *Hydrosulphuret of Soda.*—This salt may be prepared by the same processes as the hydrosulphate of potash. It is in the form of transparent and colourless crystals of an alkaline and intensely bitter taste. It is very soluble in water. When ex- Hydrosulphate.

* An anhydrous salt is one in which no water exists.

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posed to the air, it deliquesces and assumes a green colour. It is decomposed by acids, hydrosulphuric acid gas being evolved.

Hydrosulphite.

VII. *Hydrosulphite of Soda.*—Usual chemical name, *Hydroguretted Sulphuret of Soda.*—This salt may be obtained by the same process as the hydrosulphite of potash. It is of a deep-red colour, inclining to brown. Its taste is acrid, and, as it were, bitter and cooling. It stains the skin of a deep-green colour. When kept in close vessels, it deposites sulphur, becomes colourless, and is converted into hydrosulphate of soda.

Nitrate.

VIII. *Nitrate of Soda.*—Formerly called *Cubic Nitre.*—This salt may be formed by the direct combination of its constituents, or, by double decomposition, from nitrate of lime and sulphate of soda. It is in the form of transparent crystals of a cool sharp taste, somewhat more bitter than that of nitrate of potash (nitre). It is soluble in about three parts of cold water, and in less than its own weight of boiling water. When exposed to the air, it attracts moisture. It exhibits the same phenomena as the nitrate of potash when exposed to heat, except that it does not melt so easily. It is composed of

Nitric acid	54—one atom.
Soda	32—one atom.

Giving 86 for the number representing the weight of its atom.

Soda forms two salts with carbonic acid.

Carbonic acid combines in two proportions with soda, and forms carbonate and bicarbonate of soda.

IX. CARBONATE OF SODA.

Common names, *Prepared Natron.*—*Mild Fossil Alkali.*

1. Carbonate of soda; how obtained pure.

1. This salt may be obtained from impure carbonate of soda (Spanish barilla) by solution in boiling water, filtration and evaporation. Crystals of this salt will be found deposited.

2. The carbonate, here used, is a fused mass, consisting principally of carbonate of soda, but containing also charcoal, earthy substances, and some salts. The insolubility of the charcoal and earthy substances, renders it easy to separate them. The foreign salts are separated by taking advantage of their different solubility in hot and cold water, when compared with that of the carbonate.

Impure carbonate of commerce; its sources.

3. Carbonate of soda of commerce has two principal sources in nature. It is obtained from the ashes of certain marine plants, and from chloride of sodium (common salt) and sulphate of soda, by chemical decomposition. It may be

obtained also by exposing bicarbonate of soda, which is found native, to heat.

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[1] The marine plant, from which carbonate of soda is most usually obtained, is the salsola soda; but there are several other plants, which yield it in considerable abundance. The proper plants are cultivated in salt marshes by the Spaniards. They are cut down, dried like hay, and formed into bundles. Several of these bundles are set on fire and thrown into a deep pit. After they are in a state of complete combustion, others are thrown in from time to time, until the pit is full. After the incineration is complete, the impure carbonate of soda is obtained in a solid mass, and dug out and broken into pieces.

How obtained from marine plants.

The impure carbonate of soda, thus prepared, is called *barilla* in commerce. When of good quality, it is firm, hard, heavy, dry, sonorous, spongy, and internally of a blue colour, mixed with white in spots.

Forms barilla when thus obtained.

When the impure carbonate is prepared from different species of fuci, it is called kelp in England and America, and varec by the French. It is much more contaminated with foreign matters than the barilla of Spain.

When obtained by burning fuci, called kelp and varec.

[2] Chloride of sodium (common salt) may be decomposed, so as to yield carbonate of soda by the agency of three substances; namely, semi-vitrified oxide of lead (litharge), lime and iron.

Carbonate; how obtained by decomposing chloride of sodium.

When four parts of semi-vitrified oxide of lead and one part of chloride of sodium are pulverized, mixed together and macerated in water for several hours, a mutual decomposition takes place: water is decomposed; hydrochloric (muriatic) acid is formed, which combines with the protoxide of lead, in the form of an insoluble subhydrochlorate, while the carbonic acid, which exists in the semi-vitrified oxide, combines with the sodium, previously converted into soda, and forms carbonate of soda.

When a mixture of chloride of sodium and lime is formed into a paste with water, and left in a moist situation, a decomposition takes place, and there is formed chloride of calcium (muriate of lime) and carbonate of soda. The carbonic acid is obtained from the atmosphere. Carbonate of soda, however, is not manufactured by means of lime. A manufactory by this process was about to be established in France in 1782; but it appears never to have gone into operation.

Carbonate of soda is not extracted in the large way by means of iron; but the fact, that it might be obtained in this way, was ascertained by Scheele, who found that a piece of iron suspended in a cellar for fourteen days, after having

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been dipped into a solution of chloride of sodium (common salt), became incrusted with carbonate of soda.

It has been proposed to decompose chloride of sodium by means of acetate of lead (sugar of lead); or by the salt formed by combining the semi-vitrified oxide of lead (litharge) with the acid liquor obtained by distilling wood. An acetate of soda is formed in either case, which is to be exposed to a strong heat, whereby the acetic acid is partially converted into carbonic acid, and the salt itself, changed into a carbonate.

Carbonate may be obtained from sulphate of soda;

[3] Sulphate of soda may be decomposed so as to yield carbonate of soda, 1. By carbonate of potash; 2. By acetate of lime; 3. By semi-vitrified oxide of lead (litharge); 4. By charcoal.

1. By means of carbonate of potash;

The decomposition by carbonate of potash is effected, in the large way, by the following process. A boiling saturated solution of 560 pounds of impure carbonate of potash (potashes) is ladled into a boiling solution of sulphate of soda. They are agitated together, and again quickly heated to ebullition. The liquid is next drawn off into wooden cisterns lined with thick sheet-lead, and allowed to cool at a temperature not exceeding 55°. After the salt has deposited, the remaining liquor is drawn off from it, and it is washed with cold water, and afterwards boiled with clean water. This second solution is evaporated at a low red heat, until pellicles of sulphate of potash no longer form on its surface. The fire is then withdrawn, and the solution is allowed to cool pretty low, when it is ladled out into the cistern to crystallize.

2. By acetate of lime;

When the carbonate is obtained from the sulphate of soda by acetate of lime, the latter salt, with a view to economy, is formed by combining the impure acetic acid, obtained in the distillation of wood, with lime. When the acetate of lime is mixed with the sulphate, a double decomposition takes place, and acetate of soda and sulphate of lime become formed. The acetate, by being exposed to a strong heat, has its acid changed, and becomes converted into carbonate of soda.

3. By litharge; and

When the semi-vitrified oxide of lead is used to decompose the sulphate, by the mutual decomposition of these two substances a carbonate of soda becomes formed at once.

4. By charcoal.

When the sulphate is decomposed by charcoal, the carbonate becomes formed in consequence of the power, which this combustible possesses, of decomposing sulphuric acid at a high temperature. The process, in the large way, is to grind together 500 pounds of sulphate of soda and 100 pounds of charcoal, and to expose the mixture formed to

the heat of a reverberatory furnace, until it becomes pasty. It is then transferred to large casks, where it is lixiviated, evaporated and crystallized. CHAP. IV.

The carbonate of soda, when carefully prepared by means of any of the decompositions just mentioned, becomes sufficiently pure to be used in medicine and the arts. This, however, is not the case with the carbonate, obtained by the incineration of marine vegetables (barilla).

Properties of carbonate of soda.

4. Carbonate of soda is in the form of large and beautiful crystals, possessing a taste precisely similar to that of carbonate of potash. Its specific gravity is 1·35. It is soluble in two parts of cold water, and in rather less than its weight of boiling water. When exposed to the air, it effloresces and falls to powder. When subjected to a heat gradually increased, it first undergoes the watery fusion, next becomes dry, and afterwards suffers the igneous fusion and assumes the appearance of a transparent liquid. After this has taken place, if the heat be further urged, part of its acid is driven off. It contains in crystals nearly 65 per cent. of water, which is driven off when the salt is dried by heat.

Composition.

5. It is composed of

Carbonic acid	22—one atom.
Soda	32—one atom.

Giving 54 for the number representing the weight of its atom.

Its medical uses.

6. In medical properties, carbonate of soda is very similar to carbonate of potash; but in many respects it is preferable to this salt. Its form of permanent crystals enables its dose to be better regulated; and after efflorescence it may be exhibited in the form of pills. In this latter state, it forms the officinal preparation called *dried carbonate of soda.* This is best prepared by exposing the pounded crystals before the fire, and not, as the Dublin college directs, by subjecting them to heat, until they undergo the aqueous fusion and afterwards become dry.

The effloresced carbonate of soda was first recommended by Dr. Beddoes, as a substitute for the supercarbonated alkaline waters, when the latter did not agree with particular constitutions. It has a very powerful operation on the urinary organs, and is by far the most efficacious remedy known in a majority of cases of calculus, sometimes removing the disease entirely, and almost always alleviating and palliating the symptoms.

If the doctrine of the chemical physicians be correct, the carbonates of potash and of soda exert their power in calculous cases, in which the uric acid is most abundant. Now

Book I. Division II. it has been found by chemists, that more than one-half the calculi, which have come under their notice for analysis, are composed of uric acid, either alone or combined with ammonia.

The effloresced carbonate of soda may be given to the extent of one or two scruples or more during the 24 hours, made up into pills with soap.

X. BICARBONATE OF SODA.

2. Bicarbonate of soda; occurs native in Africa in masses.

1. This salt may be formed by exposing a solution of carbonate of soda to an atmosphere of carbonic acid gas. It is an uncrystallized mass, possessing a taste similar to the carbonate, but much milder. It contains about 23 per cent. of water. It occurs native in considerable quantities in Africa, in the province of Sukena, near Fezzan, and is called *trona* by the natives. It was not distinguished from the carbonate of soda of commerce until 1802, when Klaproth pointed out its distinguishing properties. It is in the form of striated masses, not altered by exposure to the air, and so hard that it is said that the walls of a fort in Africa, now in ruins, was built of it.

Composition.

2. It is composed of

Carbonic acid	44—two atoms.
Soda	32—one atom.
	76

Giving 76 for the number representing the weight of its atom. The native bicarbonate, however, contains somewhat less carbonic acid.

Medical properties.

3. This salt in solution constitutes the water of supercarbonate of soda of the Edinburgh college. It is prepared by saturating a very dilute solution of carbonate of soda with carbonic acid, made to pass through it in a stream. This solution is more pleasant, and may be taken to a greater extent, than the solution of the carbonate.

Soda forms two salts with boracic acid.

Boracic acid combines in two proportions with soda, and forms borate and subborate of soda. The subborate will be described first.

XI. SUBBORATE OF SODA.

Common name, *Borax.*

1. Subborate of soda; exists in the waters of certain lakes.

1. This salt is extracted from *tincal*, a substance which comes from the East Indies, by repeated solutions, filtrations and crystallizations. It exists in the waters of certain lakes and wells, to be found in Thibet and China. These waters are evaporated, and the salt obtained in an impure state, intermixed with sand, small stones and other impurities, when it is called *tincal.* In this state it occurs in commerce,

in masses, composed of a few large crystals, but chiefly of small ones, possessing a colour, partly white and partly green, with an appearance as if joined together by a greasy yellow substance.

2. Subborate of soda (borax) was known at least as early as the tenth century; nevertheless it was a long time before its chemical nature was ascertained. In 1712, Homberg discovered boracic acid as one of its constituents, and, without being aware of its acid nature, gave it the name of sedative salt. It was not until fifty years afterwards that Baron demonstrated that its base was soda.

3. Subborate of soda is a crystallized salt of a white colour, and styptic, alkaline taste. It possesses the property of changing vegetable blues to green. It is soluble in twenty parts of cold water, and in six parts of boiling water. In the air, it effloresces slightly. When heated, it loses nearly half its weight in water of crystallization, and assumes the form of a light, porous, very friable mass, called calcined borax. In a stronger heat, it melts into a transparent glass, without losing its solubility. It has been long familiar to artists, as a flux, to facilitate the fusion of the precious metals, and for its use in the formation of imitations of the precious stones. Its properties.

4. The medical properties of subborate of soda have been but very little investigated. It is rarely given internally. It is said to possess the properties of a diuretic and emmenagogue. It is employed in solution, or mixed with white sugar, to cleanse the mouth and fauces of infants, when these parts are affected with aphthæ. Upon the whole, it seems to deserve more notice than is generally given to it by physicians. Medical uses.

XII. *Borate of Soda.*—This salt may be formed by saturating subborate of soda with boracic acid. It has been but very imperfectly examined. 2. Borate of soda.

Phosphoric acid combines in two proportions with soda, and forms phosphate and biphosphate of soda. Soda forms two salts with phosphoric acid.

XIII. PHOSPHATE OF SODA.

Wonderful Perlated Salt of Haupt.

1. Dr. Pearson gives the following formula for the preparation of this salt. To a solution of 1400 grains of crystallized carbonate of soda in 2100 grains of water, placed in a long necked matrass, add, gradually, 500 grains of phosphoric acid of the specific gravity of 1·85. Boil the liquor for a few minutes, filtrate it while hot, and pour it into a shallow vessel, which must be placed in a cool situa- 1. Phosphate of soda.

tion. During the course of several days, crystals of phosphate of soda will be deposited.

Preparation by the apothecaries. 2. Phosphate of soda is prepared by the apothecaries by treating burnt bones (phosphate of lime) with sulphuric acid. This acid partially decomposes the phosphate, and forms with the base of the decomposed portion, an insoluble sulphate of lime (gypsum), while the disengaged phosphoric acid combines the undecomposed portion, and forms a superphosphate of lime, which remains in solution. The sulphate of lime is separated by the filter, and the remaining solution, containing the superphosphate, is decomposed by a solution of carbonate of soda. The carbonate, however, does not decompose the superphosphate completely; but its base combines with the excess of acid in this salt, and forms a phosphate of soda, which remains in solution, whereby the soluble superphosphate becomes reduced to the state of an insoluble phosphate. The phosphate of lime is now separated by the filter, and by treatment again with sulphuric acid and carbonate of soda may be made to yield a new portion of phosphate of soda. The solutions of phosphate of soda, thus obtained, are next evaporated until they deposite crystals.

Exists in urine. 3. This salt exists ready formed in urine; but as it would not yield phosphorus when treated with charcoal, it was suspected to contain an acid different from the phosphoric. Proust supposed he had obtained this acid, to which he gave the name of perlated acid; but the substance obtained by him was afterwards proved by Klaproth to be a phosphate of soda with excess of phosphoric acid, that is, a biphosphate of soda.

Its properties. 4. Phosphate of soda is in the form of crystals, possessing a cooling and urinous, but not disagreeable taste. It is soluble in about four parts of cold water, and in two parts of boiling water. Its specific gravity is 1·333. It contains about 62 per cent. of water of crystallization. When exposed to the air, it effloresces on the surface. When subjected to heat, it first undergoes the watery fusion, and afterwards, when it has reached the point of redness, melts into a white enamel. Before the blow-pipe, it fuses into a transparent globule, which becomes opaque upon cooling. It is not altered by combustibles or metals. With most of the metallic oxides, it fuses into a coloured glass. It is partially decomposed by hydrochloric (muriatic), sulphuric and nitric acids, and converted into a biphosphate.

Its medical properties. 5. Phosphate of soda was introduced into the practice of medicine, as a purgative, by Dr. Pearson. It possesses the same medical properties as sulphate of soda (Glauber's

salt), but it has this advantage over the sulphate, that it is much less disagreeable to swallow. The dose is eight or ten drachms. It may be given very conveniently in soups, to which it imparts a taste, very similar to that occasioned by chloride of sodium (common salt), and not unpleasant to the most delicate palate. Chap. IV.

XIV. *Biphosphate of Soda* is a soluble salt not easily crystallized. It may be obtained in thin scales, not unlike boracic acid. It was this salt, which Proust supposed to be the acid of the phosphate. 2. Biphosphate.

XV. *Ammonio-phosphate of Soda.*—Old names, *Microcosmic Salt; Fusible Salt of Urine.*—It was a long time known that this salt might be extracted from urine, before any correct notions of its chemical composition were formed. Margraff showed that it contained ammonia, and might be made to yield phosphorus; but it was Fourcroy, who first subjected it to a precise analysis. Its properties are those, very nearly, of phosphate of soda and phosphate of ammonia, joined together. When subjected to heat, its ammonia is driven off, and the salt is converted into a superphosphate. When exposed to the air, it suffers efflorescence and gradually loses its ammonia. Ammonio-phosphate may be extracted from urine.

XVI. *Hydrofluate of Soda.*—Usual chemical name, *Fluate of Soda.*—This salt may be formed by pouring a solution of soda into hydrofluoric acid. A combination takes place with the evolution of much heat. It is in the form of small crystals, soluble in water, and not altered by exposure to air. When heated, it decrepitates, and afterwards undergoes the igneous fusion.

XVII. *Silicofluate of Soda.*—*Fluosilicate of Soda* of Dr. Thomson.—Scheele affirms that this salt may be formed by the same means as the silicofluate of potash; but Gay-Lussac and Thenard could obtain the hydrofluate (fluate) of soda only, the salt described in the preceding paragraph.

XVIII. *Sulphocyanate of Soda.*—This is a crystallizable deliquescent salt.

XIX. *Ferrocyanate of Soda.*—Formerly called, *Triple Prussiate of Soda; Prussiate of Soda-and-Iron.*—This salt may be formed by a process similar to that given for the preparation of the ferrocyanate of potash. It is in the form of transparent crystals, of a yellow colour and bitter taste. When exposed to the air in a warm place, it falls to powder, and loses 37½ per cent. of its weight. It is soluble in 4½ parts of cold water, and in a much smaller quantity of boiling water. Its specific gravity, when in crystals, is 1·458. Ferrocyanate of soda.

XX. *Urate of Soda.*—The concretions, called chalk- Urate.

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stones, which form in joints long affected by gout, are found to consist entirely of this salt.

XXI. *Acetate of Soda.*—Formerly called, *Crystallized foliated earth.*—This salt is usually prepared by saturating acetic acid with carbonate of soda, and evaporating the solution until a pellicle forms on its surface. Upon cooling, crystals of acetate of soda are deposited. This salt has a sharp taste, approaching to bitter. It is not affected by exposure to air. It is soluble in nearly three parts of cold water. When heated, it first loses its water of crystallization, which amounts to about 40 per cent. and afterwards melts, if the heat be sufficiently urged.

Tartrate of soda.

XXII. *Tartrate of Soda.*—This salt may be formed by dissolving carbonate of soda in tartaric acid. It is in the form of needle-shaped crystals, soluble in about their weight of cold water. It is capable of combining with an excess of acid, forming a salt nearly as insoluble as the bitartrate of potash (cream of tartar). It is composed of

Tartaric acid	67—one atom.
Soda	32—one atom.
	99

Giving 99 for the number representing the weight of its atom.

XXIII. TARTRATE OF POTASH-AND-SODA.

(Common name, *Rochelle Salt.*—Formerly called, *Salt of Seignette.*)

Tartrate of potash-and-soda; how prepared.

1. This salt is usually prepared by adding gradually, as long as effervescence occurs, carbonate of soda to a solution of one part of bitartrate of potash (cream of tartar) in five parts of boiling water; and afterwards, when the saturation is complete, filtering the solution, and evaporating it to the consistence of a syrup. Upon cooling, it deposites crystals of tartrate of potash-and-soda. In this process, the salt becomes formed in consequence of the soda of the added carbonate saturating the excess of acid in the bitartrate.

2. This salt was first formed, and introduced into the practice of medicine, by Mr. Seignette, an apothecary at Rochelle, by whose name it was formerly generally known. For some time its composition was kept secret. In 1731, however, Boulduc and Geoffroy ascertained its chemical nature.

Properties.

3. Tartrate of potash-and-soda is in the form of large crystals, permanent in the air, and soluble in five times their weight of water. It has a bitter taste. When exposed to heat, it suffers decomposition. Its specific gravity is 1·757.

4. It is composed of

Tartrate of potash	115—one atom.
Tartrate of soda	99—one atom.

Giving 214 for the number representing the weight of its atom.

5. This salt is frequently used as a purgative. It is not so disagreeable to take as sulphate of soda, but more so than the phosphate; and it has this disadvantage, that it requires to be given in a larger dose than either of these salts. Medical uses.

Of the remaining salts of soda, the ammonio sulphate, sulphite, selenate, hypophosphite, arseniate, arsenite, chromate, molybdate, tungstate, purpurate, formate, oxalate, sorbate, succinate, benzoate, lactate, citrate, mellate, camphorate, malate, saclactate and suberate have been formed, and more or less accurately described, by chemists; but they are of too little importance to be described. The rest of the salts of soda, amounting in number to 24, are unknown. List of salts of soda, not described.

The salts of soda may be known by the following properties. General properties of the salts of soda.

1. They are all soluble in water, and much more so than the salts of potash.

2. When exposed to heat, they undergo the aqueous fusion, by reason of the large quantity of water of crystallization which they contain. If the heat be continued, the water is dissipated, and they assume the form of a dry white powder. When the heat is increased to redness, if the acid present in them be combustible, it is destroyed; if volatile, it is driven off; but if fixed, the whole undergoes the igneous fusion, and, on cooling, assumes the appearance of an opaque white mass, usually destitute of water.

3. Their solutions are neither precipitated by tartaric acid, nor enabled to deposite crystals of sulphate of potash-and-alumina (alum), by the addition of sulphate of alumina. These last mentioned marks distinguish them very completely from the salts of potash.

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SECTION IV.

SALTS OF LITHIA.

Salts of lithia; what compounds.

Salts of Lithia are combinations of acids with the salifiable base lithia. In consequence of the recent discovery of this substance, very few of these salts have been examined. The following are the principal ones, which have been described.

Sulphate of lithia.

I. *Sulphate of Lithia.*—This salt may be obtained from petalite, by exposing the mineral in powder for 2½ hours to heat, along with carbonate of barytes; dissolving off the excess of the barytes by hydrochloric acid added in excess, and precipitating the remainder of this substance by an excess of sulphuric acid. After the insoluble sulphate of barytes is separated, the remaining liquid will be a solution of the sulphate of lithia, containing alumina. Precipitate the alumina by carbonate of ammonia, and evaporate to dryness: the dry mass consists of this sulphate. It is a very soluble salt, possessing a purely saline taste. It suffers no change in the air. It is composed, in whole numbers, of

Sulphuric acid	40—one atom.
Lithia	18—one atom.

Giving 58 for the number representing the weight of its atom.

Nitrate.

II. *Nitrate of Lithia.*—This salt is deliquescent, and possesses a taste like nitrate of potash (nitre). When heated, it fuses into a liquid, running like water.

Carbonate.

III. *Carbonate of Lithia.*—This salt may be formed by decomposing the sulphate of lithia by acetate of barytes. In this way there becomes formed an acetate of lithia. This acetate, by being heated to redness in a platinum crucible, has its acid decomposed, and is converted into a carbonate. Carbonate of lithia has an alkaline taste. It restores the colour of turnsol, reddened by acids. It melts when exposed to a dull red heat. It is capable of attacking platinum, a property which is not possessed by the carbonate of potash or of soda.

Several other salts of lithia have been examined, such as the borate, acetate, tartrate, &c. but these salts are not of sufficient importance to be described.*

* Annales de Chimie et de Physique, tome X. (Jan. 1819.)

SECTION V.

SALTS OF LIME.

SALTS OF LIME are combinations of the different acids with the salifiable base lime. The following are the most important of these compounds. Salts of lime; what compounds.

I. *Chlorate of Lime.*—Former chemical name, *Hyperoxymuriate of Lime.*—This salt may be obtained by the following process: Pass a current of chlorine gas through a solution of lime in hot water, the temperature of which is not allowed to fall. Two substances are in this way formed; namely, chloride of calcium and chlorate of lime. In order to get rid of the chloride, boil phosphate of silver in the solution of the chloride and chlorate. This salt decomposes the chloride, and forms with it a chloride of silver and phosphate of lime, both of which are insoluble and may be separated by the filter; while the chlorate of lime remains in solution untouched, and may be obtained in crystals by evaporation. Chlorate of lime has a sharp and bitter taste, and is very deliquescent. When allowed to dissolve in the mouth, it produces a strong sensation of cold. When slightly heated, it undergoes the watery fusion. Chlorate of lime.

II. *Hydrochlorate of Lime*, it would seem, does not exist. The salt, which has heretofore been considered a hydrochlorate (muriate) of lime, does not differ, in any respect, from chloride of calcium artificially formed. Hence there is good reason to believe, that, when the attempt is made to unite hydrochloric (muriatic) acid to lime, a double decomposition takes place, which results in the formation of chloride of calcium and water. Hydrochlorate of lime does not exist.

III. *Iodate of Lime.*—This salt may be obtained by dissolving carbonate of lime (chalk) in iodic acid; or by double decomposition between a salt of lime and iodate of potash. It is usually in the form of powder, but may be obtained in crystals. It is sparingly soluble in water. It is similarly affected by the action of heat to the iodate of potash, excepting that it requires a higher temperature for decomposition.

IV. *Hydriodate of Lime.*—This salt may be formed by saturating hydriodic acid with carbonate of lime (chalk). It is a very soluble and deliquescent salt. When exposed to a strong heat, it is converted into iodide of calcium, water being at the same time formed.

V. SULPHATE OF LIME.

Syn. *Gypsum.—Selenite.—Plaster of Paris.*

Sulphate of lime occurs native.

1. Sulphate of lime occurs abundantly native in different parts of the world, and consequently is very seldom formed artificially. It was known to the ancients under the name of gypsum, but its composition was not ascertained before it was subjected to analysis by Margraff and Macquer, who proved it to be a compound of sulphuric acid and lime. Its properties were afterwards investigated with precision by Bergman.

Its properties.

2. This salt is found native in the form of crystals, sometimes exceedingly transparent. Its taste is slightly nauseous, but scarcely perceptible, unless in water impregnated with it. It is not altered by exposure to the air. When heated, it decrepitates and falls to powder, losing at the same time its water of crystallization, which amounts to about 21 per cent. In this state, it is called plaster of Paris, and is much employed in the formation of casts, and of some species of stucco, as well as for giving the last coat of plastering to the apartments of houses. It becomes well fitted for these purposes from the avidity with which it combines with, and solidifies, water, a property which enables it, when made into a paste with this liquid, to dry quickly and harden. When the sulphate is exposed to a violent heat, it melts. Before the blow-pipe, it affords an opaque vitreous globule.

3. Sulphate of lime is composed of

Sulphuric acid	40—one atom.
Lime	29—one atom.
	69

Giving 69 for the number representing the weight of its atom.

Anhydrous sulphate.

Besides the sulphate of lime, just described, which contains water, there has been found native an anhydrous sulphate. It is in the form of transparent crystals, whose broad surfaces have the appearance of pearl. Its hardness is considerable. Its specific gravity is about 2·96. It usually phosphoresces when heated. It coincides with the common sulphate in properties, and in constituents, excepting that it contains no water.

Hydrosulphate.

VI. *Hydrosulphate of Lime.*—Usual chemical name, *Hydrosulphuret of Lime.*—This salt may be formed by passing a current of hydrosulphuric acid gas through water, suspending a portion of lime. When thus obtained, it is in the form of a colourless solution, possessing an acrid, bitter taste.

VII. *Hydrosulphite of Lime*.—Usual chemical name, *Hydroguretted Sulphuret of Lime*.—This salt is formed, whenever sulphuret of lime is exposed to the air or moistened with water. The conversion takes place in consequence of the decomposition of water. It may be formed also by boiling a mixture of sulphur and lime in about ten times its weight of water. When thus prepared, it forms a solution of a beautiful orange colour, exhaling the fetid odour of hydrosulphuric acid gas. Exposed to the air, it gradually absorbs oxygen, which first combines with the hydrogen and afterwards acidifies the sulphur, whereby the hydrosulphite is converted into a sulphate. When kept in close vessels, sulphur is deposited, and it becomes changed into a hydrosulphate. Hydrosulphite.

VIII. *Nitrate of Lime*.—This salt may be formed by dissolving carbonate of lime (chalk) in nitric acid, evaporating the solution to the consistence of a syrup, and setting it aside to crystallize. It is in the form of crystals, which are exceedingly deliquescent, and possess an acrid and bitter taste. Cold water dissolves four times its weight of them, and boiling water, any quantity. When exposed to the air, it attracts moisture with such avidity as soon to liquefy. It is this affinity for moisture, which fits it for the purpose of drying gases. When heated, it readily undergoes the aqueous fusion, and afterwards, when the water of crystallization is evaporated, it becomes converted into a white powder. When strongly heated, the nitric acid is decomposed, and deutoxide of azote (nitrous gas), oxygen and azote are evolved, while pure lime is left behind. Nitrate.

IX. CARBONATE OF LIME.

(Common name, *Chalk*.)

1. Carbonate of lime exists very abundantly native, under the different names of chalk, lime-stone, marble, &c. and is, therefore, very seldom formed artificially by the chemist. It may be obtained, however, in a very pure state, in the form of a precipitate, by adding a solution of carbonate of soda, to a solution of chloride of calcium (muriate of lime). When prepared in this way, it forms the precipitated chalk of the Dublin college. Carbonate of lime exists abundantly native.

2. For the purposes of medicine, it is prepared from the impure carbonate (chalk) by trituration in an iron mortar, and subsequent levigation on a porphyry stone. The impalpable powder, thus formed, is next diffused in water, and, while this liquid continues to be loaded with the minute particles, it is poured off and allowed to settle. How prepared for the purposes of medicine.

3. Carbonate of lime is often found native in perfectly transparent crystals. It has scarcely any taste. It is inso- Properties.

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luble in cold water. Its specific gravity is about 2·7. In the air, it suffers no alteration. When exposed to heat, it first decrepitates, and loses its water of crystallization, which amounts to about eleven per cent.; and afterwards, if the heat be continued to be raised, the carbonic acid is entirely driven off, nothing remaining but pure lime.

Burning of lime explained.

4. The process of exposing different carbonates of lime (lime-stone) to a sufficient heat to drive off their acid is called calcining or burning lime. It is in this way that all the lime is formed, which is used in the arts. It continued, for a long time, a problem of considerable difficulty to ascertain what lime-stone lost in the process for converting it into lime. It had been concluded by some of the earlier chemists that it was pure water. Stahl's opinion was most generally acceded to, that the change of properties was to be ascribed to the more minute division of the particles of the lime by the action of fire. On the other hand, Boyle supposed that the new properties depended upon the fixation of fire, an opinion which was embraced by Newton.

The changes, which take place in the process, accounted for by Dr. Black.

The fallacy of all these theories was completely shown by the discovery of carbonic acid by Dr. Black, in 1755. This chemist satisfactorily proved that lime-stone was composed of lime and carbonic acid, and that, in the process of calcining, the carbonic acid was driven off, while the pure lime remained behind.

5. Anhydrous carbonate of lime is composed of

Carbonic acid	22—one atom.
Lime	29—one atom.
	51

Giving 51 for the number representing the weight of its atom.

Medical uses of carbonate of lime.

6. In medicine, carbonate of lime is an antacid and absorbent. It is therefore well suited to remove acidity of the stomach, more especially when accompanied with diarrhœa. It removes acidity, in consequence of its acid being displaced by almost every other. For exhibition, it is generally joined with sugar and aromatics, in the form of a mixture.

Lime forms four salts with phosphoric acid.

Phosphoric acid is capable of combining with lime in four proportions, forming phosphate, biphosphate, quadriphosphate and subphosphate of lime. These salts will be described in the order, in which they have been named.

X. PHOSPHATE OF LIME.

(*Earth of Bones.—Burnt Hartshorn* of the Colleges.)

1. Phosphate of lime; how prepared.

1. This salt may be prepared by exposing bones to a white heat, reducing the substance formed to powder, dissolving it in hydrochloric (muriatic) acid, and precipitating

the solution by means of ammonia. The precipitate formed, after being washed and dried, is pure phosphate of lime. CHAP. IV.

2. Bones are composed of a basis of phosphate of lime, united to a certain portion of cartilaginous matter. The exposure to a white heat burns off all the animal matters, and leaves nothing remaining but phosphate of lime. The phosphate, however, is not pure. To render it perfectly so, the impure phosphate is treated with hydrochloric (muriatic) acid, which dissolves the pure salt alone. The ammonia, which is then added, combines with the hydrochloric acid and remains in solution, and causes the dissolved phosphate of lime to precipitate.

3. This salt was first noticed in 1774 by Scheele and Gahn; but for the first precise account of its properties, chemistry is indebted to Ekeberg, Fourcroy and Vauquelin. Discovered by Scheele and Gahn.

4. Phosphate of lime is a white insoluble powder, destitute of taste, and unaltered by exposure to air. It is soluble in hydrochloric (muriatic) and nitric acids, and may be precipitated from solution in them by means of ammonia. When exposed to a very violent heat, it undergoes a kind of fusion, and is converted into a white semi-transparent porcelain. Properties.

5. According to an analysis by Berzelius, calculated in numbers, in which the equivalent number for lime is assumed, phosphate of lime is composed of

Phosphoric acid	34·3—
Lime	29·0—one atom; so that it

appears that the composition of this salt cannot be reconciled with the atomic theory.

6. Phosphate of lime has been employed as a remedy in rickets, a disease in which there appears to be a deficiency of this salt deposited in the bones. Its usefulness in this disease may be considered rather doubtful, unless the digestive powers of the system should be improved at the same time. Employed in rickets.

XI. *Biphosphate of Lime.*—This salt may be formed by digesting phosphate of lime in phosphoric acid, dissolved in hot water. The acid takes up so much of the phosphate as contains its own weight of phosphoric acid; hence this salt is a biphosphate. It does not crystallize; but, when evaporated to dryness, forms a white mass, somewhat deliquescent in the air. It is soluble in water, but does not dissolve in acids. Before the blow-pipe, it fuses into a transparent tasteless glass. 2. Biphosphate.

XII. *Quadriphosphate of Lime.—Glassy Phosphoric Acid* of the Apothecaries.—This salt may be formed by digesting, for some time, finely powdered phosphate of lime in a quantity of sulphuric acid, sufficient to saturate all the lime 3. Quadriphosphate.

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of the phosphate, and afterwards diluting the mixture with a sufficient quantity of water, and filtering. Sulphate of lime remains on the filter, and a liquid quadriphosphate passes through. In this process, the sulphuric acid abstracts three-fourths of the lime contained in the phosphate, the corresponding portion of acid combining with the remaining undecomposed phosphate. This salt, therefore, contains four times the proportional quantity of phosphoric acid that exists in the phosphate. When evaporated, it does not crystallize, but forms soft crusts, which are soluble in water, and have an acid taste. When heated, it readily melts into a transparent tasteless glass, insoluble in water and acids, and not affecting vegetable blues. It is this salt from which phosphoric acid is made; hence the name given to it by the apothecaries. It is this salt also, from which phosphate of soda is formed by double decomposition with carbonate of soda.

4. Subphosphate.

XIII. *Subphosphate of Lime.*—This salt occurs native under the names of apatite or asparagus stone.

Tungstate of lime.

XIV. *Tungstate of Lime.—Tungsten; Ponderous Stone.*—It was in this salt that tungstic acid was discovered by Scheele. It is somewhat transparent and of a yellowish grey colour. It is sometimes crystallized. It is insoluble in water, and not altered by exposure to heat.

XV. HYDROFLUATE OF LIME.

(Usual chemical name, *Fluate of Lime.*—Common names, *Fluor Spar—Derbyshire Spar.*

Hydrofluate of lime.

1. This salt exists abundantly native, and therefore need never be formed artificially by the chemist. In its pure state, free from silica, it is the salt from which hydrofluoric (fluoric) acid is obtained by the action of sulphuric acid.

Properties.

2. Hydrofluate of lime is found frequently crystallized. Its specific gravity is about 3·15. It is destitute of taste, and insoluble in water. It is not altered by exposure to air. When heated, it decrepitates and phosphoresces strongly in the dark. If it be kept hot for some time, it loses the phosphorescent property, which cannot be restored, unless its constituents are separated and then recombined. When exposed to a very intense heat, it melts into a transparent glass.

3. According to an analysis by Sir H. Davy, given in numbers, in which the acid is calculated proportionably from the equivalent number for lime, this salt is composed of

Hydrofluoric acid	10·9—
Lime	29·0—one atom.

Supposing the foregoing numbers correct, and that this salt is a compound of a single atom of each of its proximate constituents, then the equivalent number for hydrofluoric acid would be 10·9.

Silicofluate of lime. XVI. *Silicofluate of Lime.*—This salt occurs very abundantly native, and cannot be distinguished by the eye from the hydrofluate (fluate). When distilled with sulphuric acid, it yields silicofluoric acid. The difference between this salt and the last described should be attended to; as it is only from fluor spar, perfectly free from silica, that the hydrofluoric (fluoric) acid can be obtained.

XVII. *Sulphocyanate of Lime.*—This is a deliquescent salt, which may be obtained crystallized in needles.

XVIII. *Ferrocyanate of Lime.*—This salt may be formed by pouring fifty-six parts of lime-water upon two parts of perferrocyanate of iron (Prussian blue), and boiling the mixture, until it no longer alters paper stained with turmeric. It must then be filtered. The liquid, thus obtained, is a solution of this salt. It has a greenish yellow colour and an unpleasant bitterish taste. When evaporated, it yields small crystalline grains.

Oxalate. XIX. *Oxalate of Lime.*—This salt may be formed by dropping oxalic acid into a solution of any salt of lime. It immediately precipitates in the form of a white powder, which is destitute of taste. The readiness with which oxalic acid forms this salt, when it comes in contact with lime, makes it a very useful test for the presence of the latter substance.

Tartrate of lime. XX. *Tartrate of Lime.*—This salt may be formed by adding carbonate of lime (chalk) in powder to a solution, in boiling water, of bitartrate of potash (cream of tartar), as long as any effervescence ensues. The carbonate is decomposed; its acid is evolved and causes the effervescence, while its base combines with the excess of acid in the bitartrate, and falls down in the form of an insoluble tartrate of lime. This salt is a tasteless white powder, nearly insoluble in cold water. It is rendered soluble, however, by being mixed with tartrate of potash (soluble tartar) or tartrate of potash-and-soda (Rochelle salt).

Tartrate of potash-and-lime. XXI. *Tartrate of Potash-and-Lime* may be formed by adding lime-water to a solution of tartrate of potash, until a precipitate begins to appear, and allowing the mixture to deposite crystals by spontaneous evaporation.

Benzoate of lime. XXII. *Benzoate of Lime* may be worth mentioning, in order to insert the curious fact that it has been found abundantly in the urine of cows. It is in the form of white,

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shining, pointed crystals of a sweetish taste, which are much more soluble in hot than in cold water.

XXIII. *Moroxylate of Lime.*—This is the salt, found crystallized on the bark of the mulberry tree, and from which the moroxylic acid, already described, is obtained.

Kinate of lime;

XXIV. *Kinate of Lime* has already been noticed as the salt of Deschamps, from which Vauquelin first obtained the kinic acid. It may be prepared by macerating yellow Peruvian bark in water, concentrating the liquid formed, and setting it aside for spontaneous evaporation. It is in the form of white crystals, destitute of taste, and having some flexibility under the teeth. It dissolves in about five times its weight of cold water. It has been used in medicine as a substitute for the Peruvian bark, and it is said to possess all the virtues of this valuable medicine.

used in medicine.

List of salts of lime, not described.

Besides the salts of lime here mentioned, there have been described, more or less accurately by chemists, the sulphite, hyposulphite, selenate, hydroselenate, tellurate, borate, hypophosphite, arseniate, arsenite, chromate, molybdate, antimonite, urate, gallate, purpurate, sorbate, succinate, acetate, saclactate, citrate, mellate, camphorate, malate, lactate, suberate, zumate, and boletate; but these salts are not of sufficient importance to be described. The remaining salts of lime, amounting in number to 16, are unknown.

General properties of the salts of lime.

The salts of lime may be recognised by the following general properties or marks.

1. A large proportion of them are insoluble, and those which are soluble cannot be crystallized.

2. The insoluble salts, by being boiled in a solution of carbonate of potash, yield a white powder, which is soluble with effervescence in nitric acid, and has all the characters of carbonate of lime (chalk).

3. The soluble salts, upon the addition of potash or soda, let fall a white powder, which has all the properties of pure lime.

4. When oxalate of ammonia is dropped into a salt of lime, a dense white precipitate immediately appears, consisting of oxalate of lime.

SECTION VI.

SALTS OF BARYTES.

SALTS OF BARYTES are combinations of the salifiable base barytes with the different acids. The most important of these salts are the following. Salts of barytes, what compounds.

I. *Chlorate of Barytes.*—Former chemical name, *Hyperoxymuriate of Barytes.*—This salt may be obtained and purified by an analogous process to that given for forming chlorate of lime, to which salt the reader is referred. It has a sharp austere taste, and is soluble in about four times its weight of cold water. When heated, it loses 39 per cent. in oxygen gas. Chlorate of barytes.

II. *Hydrochlorate of Barytes* does not exist. This is made evident from the circumstance, that chloride of barium, artificially formed, does not differ from the compound, which is generally considered a muriate (hydrochlorate) of barytes. Hence the presumption is that hydrochloric (muriatic) acid and barytes never come in contact without mutual decomposition. Hydrochlorate does not exist.

III. *Iodate of Barytes.*—This salt may be obtained by dissolving carbonate of barytes in iodic acid. It precipitates in a powder, which, after being dried, resembles flour. When heated sufficiently, it is decomposed into oxygen, iodine and barytes.

IV. *Hydriodate of Barytes.*—This salt is in the form of crystals, very soluble in water and slightly deliquescent. When exposed to the air, it is partially decomposed; a portion of its acid is dissipated, and carbonate of barytes formed. In close vessels, it may be heated to redness without undergoing alteration; but at the same heat in the open air, it is converted into iodide of barium.

V. *Sulphate of Barytes.*—Formerly called, *Ponderous Spar.*—This salt is found abundantly in different parts of the world. Its composition was first ascertained by Gahn. It is found native crystallized, but has never been obtained in crystals by art. It is insoluble in water, and in sulphuric acid unless concentrated and boiling. When suddenly heated, it breaks to pieces and flies about with a crackling noise, owing to the conversion of the water which it contains into vapour. Before the blow-pipe, it melts into a white opaque globule. When formed into a thin cake with flour and water, and heated to redness, it acquires the property of phosphorescing in the dark. There is a variety of this Sulphate of barytes.

salt found native, called *Bologna stone*, which has this property naturally. It is composed of

Sulphuric acid	40—one atom.
Barytes	78—
	118

Supposing this salt to be a compound of a single atom of each of its ingredients, then the number representing an atom of barytes would be 78, and that for the salt, 118.

Hydrosulphate.

VI. *Hydrosulphate of Barytes.*—Usual chemical name, *Hydrosulphuret of Barytes.*—This salt may be obtained by pouring boiling water over sulphuret of barytes. As the solution obtained cools, a number of crystals form, which consist of the salt in question. In this process, by the decomposition of water, a large quantity of hydrosulphuric acid gas (sulphuretted hydrogen) becomes formed; part of which combines with the barytes and is deposited in crystals. The remainder, before it combines with the barytes, unites with an excess of sulphur, and then forms, with this alkaline base, a hydrosulphite (hydroguretted sulphuret), which remains in solution. Hydrosulphate of barytes is in the form of white crystals, possessing a silky lustre. Its solution in water has a slight green tinge, and an acrid and sulphureous taste. When exposed to the air, it is readily decomposed.

Hydrosulphite.

VII. *Hydrosulphite of Barytes.*—Usual chemical name, *Hydroguretted Sulphuret of Barytes.*—This salt remains in solution, after the crystals of hydrosulphate of barytes have deposited from the liquid, formed by treating sulphuret of barytes with boiling water. It has a green colour and an acrid taste.

Nitrate of barytes.

VIII. *Nitrate of Barytes.*—This salt may be obtained by dissolving native carbonate of barytes (witherite) in nitric acid, and evaporating the solution, until crystals form. It has a hot, acrid and austere taste. It is soluble in twelve parts of cold water, and in three or four parts of boiling water. Its specific gravity is 2·9. It undergoes very little change in the air. When exposed to heat on coals, it decrepitates, undergoes a kind of fusion, and afterwards becomes dry. In a very strong heat, its acid is dissipated, and pure barytes remains behind. It is composed of

Nitric acid	54—one atom.
Barytes	78—
	132

On the supposition that this salt contains one atom of barytes only, it is perceived, that, from its composition, the same equivalent number is deduced for the atom of barytes, as from the composition of the sulphate.

IX. *Carbonate of Barytes.—Witherite* of Mineralogists.— This salt may be prepared, artificially, by exposing barytes water to the open air, or by submitting it to the action of a stream of carbonic acid gas. It was first examined by Bergman; but Dr. Withering discovered it native, and hence its name of witherite. It exists native in crystals. It has no sensible taste. The specific gravity of native specimens is 4·3, while that of the salt, artificially formed, scarcely exceeds 3·7. It is but sparingly soluble in water, and not altered by exposure to the air. In a very violent heat along with charcoal, it is decomposed. It is not employed in medicine, but is used in the preparation of the chloride of barium, which is officinal. It is composed of

Carbonate of barytes.

Carbonic acid	22—one atom.
Barytes	78—
	100

The above numbers scarcely differ from those of the most careful analyses, heretofore made of this salt. This, therefore, is an additional evidence that 78 is the real equivalent number for barytes.

X. *Hydrofluate of Barytes.*—Usual chemical name, *Fluate of Barytes.*—When hydrofluoric (fluoric) acid is dropped into barytes water, this salt is precipitated in white flocks, which are tasteless, and insoluble in water.

Hydrofluate of barytes.

XI. *Silicofluate of Barytes.*—Usual chemical name, *Silicated Fluate of Barytes.*—When nitrate of barytes is poured into silicofluoric (fluosilicic) acid, after an interval of some minutes, this salt precipitates in the form of small hard crystals, which are insoluble in water, and in nitric and hydrochloric (muriatic) acids.

XII. *Sulphocyanate of Barytes* is a deliquescent salt in the form of crystals of a brilliant white colour.

XIII. *Ferrocyanate of Barytes.*—This salt may be formed by adding perferrocyanate of iron (Prussian blue) to hot barytes water, until the former ceases to be discoloured. The liquid thus obtained, after being filtered and gently evaporated, yields crystals consisting of this salt. It has a yellow colour, and is sparingly soluble in water. When exposed to a red heat, it is decomposed, and its acid destroyed. According to an analysis by Porrett, it is composed of

Ferrocyanate of barytes.

Ferrocyanic acid	68·2—
Barytes	78·0—

Assuming 78 for the equivalent number for barytes, it is perceived that the proportion, in which the proximate constituents of this salt combine, goes to confirm the chemical constitution, assigned by Porrett to the ferrocyanic acid.

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Acetate.

XIV. *Acetate of Barytes.*—When barytes or its carbonate is dissolved in acetic acid, or when the sulphuret of barytes is decomposed by the same acid, the liquid formed deposites this salt, by spontaneous evaporation, in transparent needle-form crystals. It has an acrid and somewhat bitter taste, and effloresces in the air. It is decomposed by almost all the sulphates; its base precipitating in combination with sulphuric acid. From this circumstance, it is often employed to detect sulphuric acid in solutions.

List of the salts of barytes not described.

Of the remaining salts of barytes, there have been more or less described by chemists, the sulphite, selenate, hydroselenate, tellurate, borate, phosphate, phosphite, hypophosphite, arseniate, arsenite, chromate, tungstate, antimoniate, antimonite, urate, purpurate, formate, oxalate, sorbate, succinate, tartrate, benzoate, saclactate, citrate, mellate, camphorate, malate, lactate, suberate, zumate, and boletate; but these salts are of too little importance to be described. The rest of the salts of barytes, amounting in number to 18, are unknown.

Chemical uses of the salts of barytes.

Several of the salts of barytes are of considerable importance to the chemist. It was by taking advantage of the insolubility of the sulphate, that Porrett was enabled to insulate the ferrocyanic acid, and Gay-Lussac, to obtain chloric acid in a separate state. The processes, by which these acids are obtained, have been already described.

They are poisonous.

All the salts of barytes are poisonous, unless the sulphate is an exception. The innocence of this salt is to be attributed to its great insolubility. What was formerly considered to be a muriate (hydrochlorate) of barytes, but now found a chloride of barium, has been used in medicine; but its utility, as a remedy, is rather equivocal. The medical properties attributed to it have been noticed under the head of chloride of barium.

The constituents of barytes may be calculated from certain data.

By the analyses, which have been selected in the present section, the reader has no doubt observed, that 78 represents the atom, or, if the term be preferred, the combining weight of barytes. This alkaline base has not been analyzed with precision, but notwithstanding the proportion in which its constituents combine may be made evident by data furnished in the analysis of chloride of barium, given at page 61. By this analysis, it is perceived, that the number representing the atom, or combining weight, of barium is 70. Now if it be supposed, agreeably to the analogy of the other alkaline salifiable bases, that barytes contains one atom only of oxygen, then the weight of its compound

atom would be 70+8=78, the same number, which is obtained by the analysis of the salts of barytes. This coincidence makes it almost certain, without recourse to analysis, that barytes is composed of 70 barium+8 oxygen. Chap. IV.

The salts of barytes may be known by the following general properties or marks. General properties of the salts of barytes.

1. A large proportion of them are insoluble in water, even larger than of the salts of lime.

2. When a small quantity of sulphate of soda (Glauber's salt) is dropped into them, there is formed a white precipitate, which is insoluble in sulphuric acid, and has the properties of sulphate of barytes.

3. When heat is applied to them, they remain unaltered, unless they should contain a combustible or volatile acid. In the first case, the acid is driven off; in the second, it is converted into carbonic acid, which combines with the barytes.

SECTION VII.

SALTS OF STRONTIAN.

Salts of Strontian are combinations of strontian with the different acids. The following are the most important of these salts. Salts of strontian, what compounds.

I. *Chlorate of Strontian.*—Former chemical name, *Hyperoxymuriate of Strontian.*—This salt may be obtained and purified by a similar process to that given for obtaining chlorate of lime. It is in the form of deliquescent crystals. On burning coals, it undergoes fusion and emits a purple flame. Chlorate of strontian.

II. *Hydrochlorate of Strontian* does not exist. When hydrochloric acid and strontian are allowed to act on each other, a double decomposition takes place, and water and chloride of strontium are formed. Hydrochlorate does not exist.

III. *Iodate of Strontian.*—This salt may be obtained by dissolving carbonate of strontian in iodic acid. It is in the form of small crystals which are soluble in water.

IV. *Hydriodate of Strontian.*—This salt is very soluble in water. It melts, when exposed to a heat rather below redness. Its fusion produces but little alteration in close vessels, but, in the open air, causes a partial decomposition, vapours of iodine being emitted.

V. *Sulphate of Strontian.*—This salt may be formed Sulphate.

artificially by dropping sulphuric acid into strontian water. It occurs abundantly native, usually in the form of crystals, in different parts of the world. It is destitute of taste, and scarcely soluble in water. Sulphuric acid dissolves it readily by the assistance of heat; but it is separated again by the addition of water. It is composed of

Sulphuric acid	40—one atom.
Strontian	52—
	92

The numbers, above given, scarcely differ from the most accurate analyses, hitherto made of this salt. Supposing one atom only of strontian in its composition, then the number representing the atom of strontian would be 52.

Nitrate. VI. *Nitrate of Strontian.*—This salt may be formed, either by dissolving carbonate of strontian in nitric acid, or decomposing the sulphuret of strontian by means of the same acid. In either case, the liquid obtained is evaporated to dryness, re-dissolved in water, and then evaporated slowly, until crystals form. This salt has a strong, pungent, cooling taste. Its crystals are perfectly transparent, and possess a great deal of lustre. Its specific gravity is 3·006. It is soluble in its own weight of cold water, and in a little more than half its weight of boiling water. In the air, it undergoes no change. It deflagrates on hot coals; and, in a crucible exposed to heat, it first decrepitates gently, and then melts. At a red heat, it boils and its acid is dissipated. If a combustible be brought in contact with it at this time, it deflagrates with a vivid red flame. When one of its crystals is put into the wick of a burning candle, it communicates a purple colour to its flame. It is composed of

Nitric acid	54—one atom.
Strontian	52—
	106

The numbers, above given, scarcely differ from those of the best analyses, heretofore made of this salt and it is perceived that the equivalent number for strontian turns out to be the same as when deduced from the sulphate.

Carbonate. VII. *Carbonate of Strontian.*—This salt has been found native at Strontian and Leadhills, in Scotland. It was first distinguished from carbonate of barytes, in 1798, by Crawford. It is usually found in striated, semi-transparent masses of a greenish tinge. Its specific gravity is about 3·66. It has no taste, and is nearly insoluble in water. It is not altered by exposure to air. When made into a paste with

charcoal and strongly heated, it is entirely decomposed. It is composed of *Chap. IV.*

Carbonic acid	22—one atom.
Strontian	52—
	74

As the same quantity of strontian combines with an atom of carbonic acid, as with an atom of sulphuric or nitric acid, the equivalent number for an atom of this base may be safely taken at 52; and 74 may be considered as the number representing the weight of an atom of carbonate of strontian.

Hydrofluate.

VIII. *Hydrofluate of Strontian.*—Usual chemical name, *Fluate of Strontian.*—When hydrofluoric (fluoric) acid is dropped into strontian water, this salt precipitates in the form of a white powder, insoluble in water, but soluble in hydrofluoric (fluoric), nitric, and hydrochloric (muriatic) acids.

Ferrocyanate.

IX. *Ferrocyanate of Strontian.*—Usual chemical names, *Triple Prussiate of Strontian; Prussiate of Strontian-and-Iron.*—This salt may be formed by adding perferrocyanate of iron (Prussian blue) to hot strontian water, as long as the former becomes discoloured, and evaporating gently the liquid obtained, until it deposites crystals. It does not crystallize nearly so readily as the ferrocyanate of barytes. When evaporated to dryness, it does not deliquesce. It is soluble in less than four times its weight of cold water.

List of salts of strontian not described.

Of the remaining salts of strontian, the following have been more or less examined by chemists; namely, the hyposulphite, hydrosulphate, hydrosulphite, selenate, hydroselenate, borate, phosphate, hypophosphite, arseniate, arsenite, chromate, sulphocyanate, urate, purpurate, oxalate, succinate, acetate, tartrate, citrate and zumate; but these salts are of too little importance to be described. The rest of the salts of strontian, amounting to 34, are unknown.

The composition of strontian may be calculated.

From the analyses, which have been given of the salts of strontian, it appears that the atom or combining weight of strontian is represented by 52. By the composition of the chloride of strontium, it appears that the atom of strontium is represented by 44. Now, if it be supposed that strontian contains one atom of oxygen, then its composition will be 44 strontium + 8 oxygen = 52. This composition agreeing precisely with the equivalent number for strontian, deduced from its salts, its correctness may be considered as almost certain.

General properties.

The salts of strontian may be distinguished by the following properties or marks.

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of the salts of strontian.

1. They are in general more soluble than the salts of barytes, but less so than the salts of lime.

2. Their solutions in water are precipitated by the sulphates, phosphates, and oxalates.

3. They are distinguished from the salts of barytes, very readily, by means of oxalate of ammonia. This salt, when dropped into the salts of strontian, produces no precipitate; but when added to the salts of barytes, a precipitate immediately appears.

4. A piece of paper, dipped in a salt of strontian and set on fire, burns with a red flame; but after being dipped into a salt of barytes, it burns with a yellow flame.

5. The salts of strontian are not poisonous, as is the case with the salts of barytes.

SECTION VIII.

SALTS OF MAGNESIA.

Salts of magnesia; what compounds.

Salts of Magnesia are combinations of magnesia with the different acids. The following are the most important of these salts.

Chlorate of magnesia.

I. *Chlorate of Magnesia.*—Former chemical name, *Hyperoxymuriate of Magnesia*.—This salt may be prepared and purified in the same manner as the chlorate of lime, which it resembles very much in properties.

Hydrochlorate does not exist.

II. *Hydrochlorate of Magnesia* does not exist. What had been previously considered a muriate (hydrochlorate) of magnesia does not differ from chloride of magnesium, artificially formed. Hence there is reason to believe that hydrochloric (muriatic) acid and magnesia never act upon each other without mutual decomposition.

III. *Hydriodate of Magnesia.*—This is a deliquescent, difficultly crystallizable salt, which is decomposed when heated to redness, its acid being driven off.

IV. SULPHATE OF MAGNESIA.

(Common names, *Vitriolated Magnesia—Epsom Salt.*)

Sulphate of magnesia; Preparation.

1. This salt is obtained, in great abundance, by evaporation, from the bittern, left after the extraction of chloride of sodium (common salt) from sea water. It exists plentifully in the springs at Epsom in England, from which it is obtained in considerable quantity, mixed with a portion of sulphate of soda (Glauber's salt).

2. It is obtained in Italy from certain minerals contain-

ing sulphur and magnesia. These minerals are first roasted, and afterwards moistened with water and exposed to the air. By this treatment, the sulphur becomes acidified, and the sulphate of magnesia effloresces on their surface. The salt is afterwards purified by solution in water, by treatment with lime to precipitate any metallic substance, and by repeated crystallizations. CHAP. IV.

3. Sulphate of magnesia has an intensely bitter taste. Its specific gravity is 1·66. It dissolves in its own weight of cold water, and in rather less than two-thirds of its weight of boiling water. When exposed to the air, it effloresces and is reduced to powder. Its deliquescence is owing to the presence of chloride of magnesium (muriate of magnesia.) When exposed to heat, it undergoes the watery fusion, and afterwards, if the temperature be increased, its water, which amounts to about half its weight, is driven off, and the salt becomes dry; but it is not decomposed, however high the temperature may be raised. Before the blow-pipe, it melts with difficulty into a vitreous globule. It is composed of Properties. Composition.

Sulphuric acid	40—one atom.
Magnesia	20—
	60

Supposing this salt to contain but one atom of its base, then the equivalent number for magnesia would be 20.

4. In medicine, sulphate of magnesia is a mild and gentle purgative, operating, in general, without occasioning griping or sickness of stomach. It may be so managed, however, as to promote evacuation through other channels. If the patient be kept warm after its exhibition, it promotes perspiration; and, if he take exercise in the cool air, it produces discharges through the kidneys. Its dose is from six drachms to one ounce. Medical properties.

V. *Nitrate of Magnesia.*—This salt may be prepared by saturating nitric acid with magnesia, and evaporating the solution thus obtained to a proper consistency. It precipitates in the form of crystals, which have a bitter and disagreeable taste. It dissolves in a little more than its weight of cold water, and in a smaller proportion of boiling water. In the air, it is deliquescent. When exposed to heat, it undergoes the watery fusion, and, if the heat be continued, loses its water of crystallization, amounting to about thirty per cent. and is converted into a dry powder. In a strong heat, its acid is decomposed and driven off, while its base remains behind in a state of purity. It is composed of Nitrate of magnesia.

Nitric acid	54—one atom.
Magnesia	20—
	74

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If this salt contain but one atom of its base, then the equivalent number for magnesia will be twenty, exactly the same number which is deduced from the composition of the sulphate.

Magnesia forms two salts with carbonic acid.

Carbonic acid combines in two proportions with magnesia, and forms carbonate and bicarbonate of magnesia.

VI. CARBONATE OF MAGNESIA.

(Commonly called, *White Magnesia.*)

1. Carbonate of magnesia; how obtained.

1. This salt may be obtained by mixing together, solutions of equal parts of sulphate of magnesia (Epsom salt) and carbonate of potash (salt of tartar), and boiling them for some time; a white precipitate is formed, which consists of carbonate of magnesia. It must be washed repeatedly with water, until this liquid comes off tasteless.

2. The explanation of the above process is this: By the mutual action of the salts employed, a double decomposition takes place, and there is formed sulphate of potash (vitriolated tartar) and bicarbonate of magnesia. Both these salts remain in solution at first; but, by the subsequent boiling, some carbonic acid is driven off, whereby the bicarbonate is converted into a carbonate, which, being insoluble, immediately forms a precipitate. It requires to be washed, in order to dissolve away any sulphate of potash, with which it may be mixed.

How obtained in the large way.

3. Carbonate of magnesia, in the large way, is generally obtained from bittern, or the liquor which is left after the crystallization of chloride of sodium (common salt), in salt works. This liquor contains chloride of magnesium (muriate of magnesia) and sulphate of magnesia.

Another method.

4. It may be obtained also in the process for forming sulphate of ammonia, for the purpose of forming afterwards hydrochlorate of ammonia (sal ammoniac) by double decomposition with chloride of sodium (common salt). This sulphate is prepared by double decomposition, from sulphate of magnesia (Epsom salt) and carbonate of ammonia (mild volatile alkali); and there is obtained, at the same time, a carbonate of magnesia. By this process, it was manufactured by Dr. Campbell in England.

5. This salt exists abundantly native, in the magnesian lime-stone of England. It has been for a long time known, but its composition was first ascertained by Dr. Black.

Properties.

6. Carbonate of magnesia is a very light, white, opaque substance, destitute of taste or smell. It is soluble in about 480 times its weight of water.

7. It is composed of

Carbonic acid	22—one atom.
Magnesia	18—
	40

This analysis gives 18 for the equivalent number of magnesia. This number does not agree very well with that deduced from the composition of the sulphate and nitrate.

8. As a medicine, the properties of carbonate of magnesia are those of a purgative and corrector of acidity. Its purgative property, however, is not very manifest, unless it meet with an acid in the stomach; in which case, it is decomposed, and its base, combining with such acid, forms a new compound, which often proves purgative. When such a decomposition takes place, the extrication of carbonic acid will sometimes create a troublesome flatulence. Medical properties.

VII. BICARBONATE OF MAGNESIA.

1. This salt may be obtained by mixing together, in solution, 123 parts of sulphate of magnesia (Epsom salt) and 136 parts of carbonate of soda, and filtering the liquid formed. In a few days, the bicarbonate falls down in crystals. It may be formed also by passing carbonic acid into water, in which carbonate of magnesia has been diffused. The carbonate is thereby converted into a bicarbonate, and dissolves in the water. 2. Bicarbonate; how obtained.

2. This salt has little taste. It is soluble in about 48 parts of cold water when in crystals; but in powder, it requires at least ten times as much for solution. When exposed to the air, it effloresces and falls into powder. It contains about 25 per cent. of water. When heated, it decrepitates, becomes converted into a powder and is decomposed. Properties.

3. It is composed of

Carbonic acid	44—two atoms.
Magnesia	22—
	66

By this analysis, 22 turns out to be the equivalent number for magnesia, which differs from that deduced from the composition of the sulphate and nitrate. These two salts give it at 20. There is reason, however, to consider 20 as the correct number, since the mean of the numbers, afforded in the analysis of the two carbonates, is exactly 20.

4. There can be very little doubt that the bicarbonate of magnesia would prove a very excellent substitute for the common carbonate as a medicine. The additional quantity of carbonic acid, which it contains, could not fail to make A good substitute for the carbonate as a medicine.

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it better suited to some cases, in which the common carbonate is used, and its solubility, in this state of preparation, would render it much less disagreeable to be swallowed. There is very little question that the different preparations of magnesia in the liquid form, sold in the United States, are nothing else but solutions of bicarbonate of magnesia.

Phosphate of magnesia.

VIII. *Phosphate of Magnesia.*—When the solutions of phosphate of soda and sulphate of magnesia (Epsom salt) are mixed together, no apparent change takes place at first. In a few hours, however, this salt forms in large transparent crystals, possessing very little taste, but leaving a cooling and sweetish impression on the tongue. It is soluble in about 15 parts of cold water, and in a smaller quantity of boiling water. In the open air, it loses its water of crystallization and falls to powder. It has been detected in the bones of all animals, except those of man.

Hydrofluate.

IX. *Hydrofluate of Magnesia.*—Usual chemical name, *Fluate of Magnesia.*—This salt may be formed by dissolving carbonate of magnesia in hydrofluoric (fluoric) acid. When thus obtained, it is a tasteless white powder, insoluble in water, and scarcely soluble in acids. When formed, by double decomposition, from hydrofluate (fluate) of potash and sulphate of magnesia, it is at first in the form of a gelatinous mass, soluble in acids; but after it has become dry, it is insoluble.

X. *Tartrate of Magnesia.*—This salt is insoluble, unless it contains an excess of acid, in which case it may be obtained by evaporation in small crystals.

Tartrate of potash-and-magnesia.

XI. *Tartrate of Potash-and-Magnesia.*—This salt may be formed by dissolving magnesia, or its carbonate, in bitartrate of potash (tartar). The extra atom of tartaric acid, in the bitartrate, becomes saturated with magnesia, and thus the triple salt is formed. Its properties have not been investigated. Its constituents render it deserving of a careful examination by physicians, with a view to its medicinal powers.

List of the salts of magnesia not described.

Besides the salts of magnesia just described, there have been more or less examined by chemists, the ammonio-sulphate, potasso-sulphate, soda-sulphate, sulphite, ammonio-sulphite, hydrosulphate, hydrosulphite, selenate, hydroselenate, ammonio-nitrate, borate, ammonio-phosphate, arseniate, chromate, molybdate, tungstate, sulphocyanate, ferrocyanate, urate, purpurate, gallate, oxalate, sorbate, succinate, acetate, benzoate, saclactate, citrate, camphorate, malate, lactate, ammonio-lactate, suberate, and

zumate. The rest of the salts of magnesia, amounting in number to 27, are unknown. Chap. IV.

Constituents of magnesia, deduced theoretically.

Assuming 20 as the true number representing the atom or combining weight of magnesia, what composition can be reasonably assigned to this substance, in confirmation of its correctness? In answer to this question, it may be said, that the atom of magnesium, as deduced from its chloride, turns out to be 12. Now if it be supposed, that magnesia is a compound of one atom of magnesium and one atom of oxygen, its equivalent number will be $12+8=20$, the same number as given by the salts of magnesia. This, therefore, may be considered the true composition of magnesia.

General properties of the salts of magnesia.

The salts of magnesia may be known by the following general properties or marks.

1. A large proportion of them are soluble in water and capable of crystallization.

2. They let fall a white flocky precipitate, when potash or soda, or the carbonates of these alkaline bases, are dropped into their solutions. When the pure bases are used, the precipitate is pure magnesia; but when the carbonates are employed, the precipitate is carbonate of magnesia.

3. If phosphate of soda be dropped into a salt of magnesia, no apparent change takes place; but afterwards, if ammonia be added, a triple salt, composed of phosphoric acid, ammonia and magnesia, will fall in the form of a white precipitate.

SECTION IX.

SALTS OF YTTRIA.

Salts of yttria; what compounds.

Salts of Yttria are combinations of the earthy salifiable base yttria with the different acids. Five only of these compounds will be described.

Hydrochlorate of yttria.

I. *Hydrochlorate of Yttria.*—Former chemical name, *Muriate of Yttria.*—This salt does not crystallize, but attracts moisture very rapidly from the atmosphere and runs into a jelly. When exposed to a gentle heat, it dries with difficulty, and afterwards melts.

Sulphate.

II. *Sulphate of Yttria.*—When yttria is dissolved in sulphuric acid, this salt crystallizes in small brilliant white grains. Its taste is sweet and astringent, and its colour, light-red. It is not altered by exposure to air. Its specific gravity is 2·791. It is soluble in about 30 parts of cold water. When exposed to a red heat, it suffers decomposition.

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Nitrate.

III. *Nitrate of Yttria.*—This salt may be obtained by dissolving yttria in nitric acid. The solution has a sweet astringent taste. It can hardly be obtained in crystals. When exposed to the air, it attracts moisture and deliquesces.

IV. *Carbonate of Yttria.*—This salt may be obtained by precipitating any acid solution of yttria by means of carbonate of potash or of soda. It is a white, tasteless, insoluble powder.

V. *Hydrofluate of Yttria.*—Usual chemical name, *Fluate of Yttria.*—This salt may be formed by decomposing hydrofluate (fluate) of potash by means of hydrochlorate (muriate) of yttria. It is a white, tasteless powder, totally insoluble in water.

List of the salts of yttria not described.

Of the remaining salts of yttria, there have been more or less examined by chemists, the hydrosulphate, selenate, phosphate, arsenite, chromate, oxalate, succinate, acetate and tartrate; but these are not of sufficient importance to be described. The rest of the salts of yttria, amounting in number to 49, are unknown.

General properties of the salts of yttria.

The salts of yttria may be known by the following properties or marks.

1. They are precipitated by phosphate of soda, carbonate of soda, oxalate of ammonia, and tartrate of potash (soluble tartar).

2. They bear considerable resemblance to the salts of lime, in the degree of their solubility; but they may be distinguished from these salts, by being converted into a sulphate, which is soluble and has a sweet taste, very different from the sulphate of lime.

SECTION X.

SALTS OF GLUCINA.

Salts of glucina; what compounds.

SALTS OF GLUCINA are combinations of glucina with the different acids. Five only of these compounds will be described.

Sulphate of glucina.

I. *Sulphate of Glucina.*—When glucina is dissolved to saturation in sulphuric acid, and the solution evaporated, this salt forms in needle-shaped crystals. It has a very sweet and somewhat astringent taste. It is soluble in water. By heat, it undergoes the watery fusion, and afterwards its

water is dissipated, and it is converted into a powder. At a red heat, its acid is driven off, and nothing remains but pure glucina. Chap. IV.

Nitrate. II. *Nitrate of Glucina.*—This salt may be formed by saturating nitric acid with glucina. It cannot be obtained in crystals. When its solution is evaporated, it gradually assumes the form of a white powder. It has a sweet and astringent taste, and is very soluble in water. When exposed to the air, it attracts moisture very rapidly. When heated, it readily melts; and if the temperature be increased, its acid is dissipated, while the pure earthy base remains behind.

Carbonate. III. *Carbonate of Glucina.*—This salt may be obtained by precipitating an acid solution of glucina, by means of the carbonate of potash or of soda. It is in the form of a soft, white, and exceedingly light powder, which has a greasy feel. It is destitute of taste, and insoluble in water. It is not altered by exposure to the air. It is easily decomposed when submitted to the influence of heat, its acid being driven off.

Phosphate. IV. *Phosphate of Glucina.*—When phosphate of soda is added to a solution of glucina in sulphuric, nitric or hydrochloric (muriatic) acid, this salt precipitates in the form of a tasteless white powder, which is insoluble, unless it contains an excess of acid. It is incapable of crystallizing, and is not altered by exposure to the air.

Hydrofluate. V. *Hydrofluate of Glucina.*—Usual chemical name, *Fluate of Glucina.*—This salt may be formed by dropping hydrofluate (fluate) of potash into hydrochlorate (muriate) of glucina. When first precipitated, it is in the form of a jelly, which dissolves in hot water, and deposites in small crystals as the solution cools.

List of salts of glucina not described. Of the remaining salts of glucina, there have been more or less examined, the hydrochlorate, hydrosulphate, seleniate, chromate, chromo-sulphate, oxalate, succinate, and acetate; but these are not of sufficient importance to be inserted. The rest of the salts of glucina, amounting in number to 49, are unknown.

General properties of the salts of glucina. The salts of glucina may be known by the following properties or marks.

1. They are much more soluble than the salts of yttria, and but a small proportion of them are capable of crystallizing.

2. They are precipitated by oxalate of ammonia, or by tartrate of potash; which circumstances sufficiently distinguish them from the salts of yttria.

SECTION XI.

SALTS OF ALUMINA.

Salts of alumina; what compounds.

Salts of Alumina are combinations of alumina with the different acids. The following are the principal of these compounds.

Hydrochlorate of alumina.

I. *Hydrochlorate of Alumina.*—This salt may be obtained by dissolving alumina in hydrochloric (muriatic) acid. It always contains an excess of acid. It is scarcely capable of crystallizing. It is either in the form of a gelatinous mass or of a white powder. It is extremely soluble in water, and deliquescent in the air. When exposed to heat, it melts; its acid being dissipated, while its earthy base remains behind.

Sulphate.

II. *Sulphate of Alumina.*—This salt may be formed by dissolving alumina in sulphuric acid, evaporating the solution formed to dryness, and afterwards dissolving the dry mass in water, and evaporating the solution until it crystallizes. It is very soluble in water, and has an astringent taste. It does not crystallize without difficulty. Its crystals consist of thin plates, which are soft and pliant, and have a pearly lustre. It is not altered by exposure to the air. When somewhat heated, it loses its water of crystallization and falls to powder. In a strong heat, its acid is decomposed and dissipated, and the pure earthy base remains behind. It was never properly distinguished from the different alum salts, before the memoirs of Vauquelin and Chaptal appeared on the nature of alum.

III. { SUPERSULPHATE OF ALUMINA-AND-POTASH. SUPERSULPHATE OF ALUMINA-AND-AMMONIA.

Chemical nature of alum.

1. As these salts scarcely differ in properties, and can be distinguished only by analysis, they will be described together. They constitute, either singly, or mixed in different proportions, the very useful substance called alum. The account of alum, therefore, will be the account of these two salts.

Alum; how obtained.

2. Alum is obtained from different earths, whose principal ingredients are sulphur, and clay or alumina. These earths are called aluminous, and are of several different kinds. Some of them contain sulphuret of iron (pyrites), and others, variable quantities of bituminous matters. The outline of the process is this: The alum earth is roasted, in order to acidify the sulphur which it contains. The sulphuric acid, thus formed, combines with the alumina,

which, in this state of combination, becomes soluble. The roasted earth is next lixiviated, and the solution obtained, concentrated by evaporation, and afterwards putrid urine or a solution of common potash, added. The alum becomes deposited in crystals, which are sometimes mixed with those of sulphate of iron (green vitriol), in case the aluminous earth should have contained sulphuret of iron.

Use of potash and ammonia in the process, explained.

3. The sulphate of alumina, first formed, after being lixiviated, requires to be mixed with potash or ammonia, or some substance which furnishes these alkaline bases; for it must be recollected, that alum is a triple salt, which contains either potash or ammonia, or both these substances, as well as alumina, combined with sulphuric acid. When putrid urine is used in the manufacture, ammonia is the second base which the alum contains; as this secretion, after having undergone the putrefactive process, contains a large proportion of ammonia, and only a minute quantity of potash.

Another method for forming alum.

4. Sometimes alum is prepared by burning sulphur in chambers, whose floors are covered with fragments of a very pure clay, which has been previously made up into balls with water, and ignited in a furnace. The acidified sulphur is imbibed by the clay; and after the fragments are completely covered by an efflorescence of sulphate of alumina, they are removed and exposed to the open air for some time under a shed, where the acid is enabled to penetrate them more thoroughly. As soon as this is completed, the clay is lixiviated, and crystallized by the usual additions. This is an imperfect outline of Chaptal's method.

History of alum.

5. It is not certainly ascertained that alum was known to the ancients. The στυπτηρια of the Greeks, the *alumen* of the Romans, was a native substance, which appears to have been sulphate of iron (green vitriol), or a compound nearly allied to this salt. According to Beckman, the credit of the discovery of alum belongs to the Asiatics, from whom it continued to be imported until the 15th century; at which period a number of alum works were established in Italy. In the 16th century, alum was manufactured in Germany and Spain; and in England, for the first time, during queen Elizabeth's reign.

Its chemical nature discovered by gradual steps.

6. The chemical nature of alum was discovered only by very gradual steps. The fact was known to the alchemists, that it contained sulphuric acid. In 1754, Margraff proved that it contained an earth, which is the same with that which constitutes the basis of clay. But these substances could not be its only ingredients; since it was not possible to form alum by combining sulphuric acid with alumina. It was known to manufacturers, that the addition of potash or

ammonia, or of some substance containing these alkaline bases, to the aluminous lixivium, was absolutely necessary for the formation of alum; unless indeed the earth, from which it may have been manufactured, should contain potash. Various conjectures were made, as to the part which potash performed in the manufacture; but nothing decisive was known on the subject, before Vauquelin and Chaptal published their experiments, by which they proved incontestably that alum is a triple salt, composed of sulphuric acid, united to alumina and potash, or alumina and ammonia.

Alum described.

7. Alum is a crystallized salt, capable of changing vegetable blues to red, and always containing an excess of acid. Its taste is sweetish and very astringent. Its specific gravity is 1·71. When exposed to the air, it effloresces slightly. It is soluble in from 15 to 20 times its weight of cold water, and in three-fourths of its weight of boiling water. When exposed to a gentle heat, it undergoes the watery fusion. In a pretty strong heat, it foams and swells, and loses about 44 per cent. in water of crystallization. The residue, after this exposure to heat, is called calcined or burnt alum. In a very violent heat, it has the greater part of its acid dissipated.

Homberg's pyrophorus; how formed.

The principal ingredient in Homberg's pyrophorus is alum. To form this substance, three parts of alum and one part of sugar or flour are melted in an iron ladle, and the heat continued, until the mixture becomes blackish and ceases to swell. It is then reduced to fine powder, and exposed to a sand heat in a phial, until a blue flame issues from its mouth. After burning a minute or two, it is withdrawn from the fire and allowed to cool. The substance, thus formed, is the pyrophorus. It has the singular property of catching fire, whenever it is exposed to the open air, especially if the atmosphere be moist.

Its discovery.

This substance was accidentally discovered, about the beginning of the 18th century, by Homberg. It was for a long time supposed that alum is an essential ingredient in it; but it has been ascertained, that, if alum be deprived of its potash, it will not form pyrophorus. According to Davy and Coxe, its properties depend upon the presence of a small portion of potassium, which they suppose to be developed, during a partial decomposition of the potash, by the agency of heat.

When a certain excess of potash is added to an alum liquor, the salt does not crystallize in the usual form, and, from the shape of its crystals, is called cubic alum. If a still larger quantity be added, the liquor deposites no crys-

tals, but lets fall a number of flakes. Both these substances may be considered as varieties of alum. Chap. IV.

8. Supersulphate of alumina-and-potash is composed of

Composition of one species of alum.

Sulphuric acid	160—four atoms.	
Alumina	50—	
Potash	46—one atom, nearly.	

Supposing three atoms of sulphuric acid combined with the alumina, and the remaining atom, with the atom of potash; then the composition of this salt would be

Sulphuric acid	120—three atoms.
Alumina	50—

Forming 170 sulphate of alumina; combined with

Sulphuric acid	40—one atom.
Potash	46—one atom, nearly.

Forming 86 sulphate of potash. And, supposing the sulphate of alumina to contain three atoms of earthy base, then the atom or combining weight of alumina would be represented by 16·6.

9. Alum is of indispensable utility in the arts. To enumerate all its uses could not be done, consistently with the plan of this compendious work. It is employed principally in tanning, and as a mordant in dyeing.

Alum, very useful in the arts;

10. In the materia medica, alum is a very powerful astringent. On account of this property, it was formerly used internally for restraining hæmorrhages; but it now yields in efficacy to many other articles. Its dose is from ten to twenty grains. In large doses, it is apt to produce nausea. Externally, it is used in solution, as a repellant lotion and in astringent collyria. It forms a good injection in certain stages of gleet, and in fluor albus. It enters into the composition of several pharmaceutical preparations of acknowledged efficacy. When deprived of its water of crystallization, in the form of burnt alum, it acts as an escarotic.

an active article in the materia medica.

IV. *Sulphate of Alumina-and-Potash; Sulphate of Alumina-and-Ammonia.*—Formerly called, *Alum saturated with its earth.*—These two salts may be described together, as they are formed by saturating different species of alum with alumina. They are prepared by boiling a solution of alum with pure alumina. They are both in the form of a tasteless insoluble powder, which is incapable of crystallizing. They are not altered by exposure to the air. In a very violent heat, part of their acid is driven off. The addition of sulphuric acid converts them into alum. They have not heretofore been applied to any useful purpose.

Alum saturated with its earth.

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Nitrate of alumina.

V. *Nitrate of Alumina.*—When alumina is dissolved in nitric acid, this salt may be obtained in crystals by evaporation. It has an acid and astringent taste. It is exceedingly soluble in water. In the air, it attracts moisture and deliquesces. When heated, the acid is readily driven off, and the earthy base remains behind in a state of purity.

Carbonate.

VI. *Carbonate of Alumina.*—It is not completely settled whether this salt can exist. In the dry state, it cannot be obtained; but it has been ascertained, that water saturated with carbonic acid is capable of dissolving a portion of alumina. The combination, however, is destroyed by mere exposure to air.

VII. *Phosphate of Alumina.*—This salt may be formed by saturating phosphoric acid with alumina. It is a tasteless insoluble powder.

VIII. *Hydrofluate of Alumina.*—Usual chemical name, *Fluate of Alumina.*—This salt may be formed by pouring hydrofluate (fluate) of potash into a solution of supersulphate of alumina-and-potash (alum). It is in the form of a white powder, insoluble in water, but soluble in an excess of acid. After having been well dried, it is nearly insoluble in acids.

Acetate.

IX. *Acetate of Alumina.*—When acetic acid is digested upon alumina recently precipitated, by evaporation this salt may be obtained in needle-form crystals, which have an astringent taste, and are very deliquescent in the air. This salt is employed in the processes of dyers and calico printers.

Mellate of alumina, the mellite of mineralogists.

X. *Mellate of Alumina.*—This salt exists native under the name of mellite. It is the only substance in which mellitic acid has hitherto been found. It may be formed artificially by dropping mellitic acid into a solution of sulphate of alumina. When thus formed, it assumes the appearance of a white flaky powder.

List of salts of alumina not described.

Besides the salts of alumina just described, there have been more or less noticed by chemists, the sulphite, selenate, borate, arseniate, tungstate, sulphocyanate, urate, purpurate, gallate, oxalate, sorbate, succinate, tartrate, potasso-tartrate, benzoate, saclactate, camphorate, malate, suberate and zumate; but these salts are not of sufficient importance to be described. The rest of the salts of alumina, amounting in number to 36, are unknown.

General properties of the salts of alumina.

The salts of alumina may be known by the following properties or marks.

1. A large majority of them are soluble in water, and but very few capable of crystallizing.

2. They have a sweet and astringent taste. In this particular, however, they resemble the salts of yttria and glucina.

3. They are not precipitated by oxalate of ammonia or tartaric acid; which circumstances sufficiently distinguish them from the salts of yttria.

4. If sulphuric acid, and afterwards sulphate of potash be added to a salt of alumina, crystals of supersulphate of alumina-and-potash (alum) will speedily make their appearance.

SECTION XII.

SALTS OF ZIRCONIA.

Salts of zirconia, what compounds.

SALTS OF ZIRCONIA are combinations of the different acids with the salifiable base zirconia. Only five of these compounds will be noticed.

Hydrochlorate of zirconia.

I. *Hydrochlorate of Zirconia.*—Usual chemical name, *Muriate of Zirconia.*—When hydrochloric (muriatic) acid is poured upon newly precipitated zirconia, the latter becomes dissolved, and, by proper evaporation, this salt may be obtained in small transparent needle-form crystals, which become opaque in the air. It is colourless, and very soluble in water. Its taste is very astringent. When exposed to heat, it is decomposed.

Sulphate.

II. *Sulphate of Zirconia.*—This salt may be formed by dissolving zirconia in sulphuric acid, and evaporating the solution to dryness. It is usually in the form of a white powder; but it may be obtained in crystals. It is tasteless, insoluble in water, and not altered by exposure to the air. By exposure to heat, its acid is readily driven off.

Nitrate.

III. *Nitrate of Zirconia.*—This salt may be formed by dissolving newly precipitated zirconia in nitric acid. It always contains an excess of acid. It is but sparingly soluble in water. Its taste is astringent. When exposed to heat, it suffers decomposition.

IV. *Carbonate of Zirconia.*—This salt may be formed by precipitating an acid solution of zirconia by means of the carbonate of potash or of soda. It is a tasteless white powder. When heated, its acid is driven off.

V. *Hydrofluate of Zirconia.*—Usual chemical name, *Fluate of Zirconia.*—This salt is precipitated in the form of an insoluble white powder, when hydrofluate (fluate) of potash is added to hydrochlorate (muriate) of zirconia.

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List of salts of zirconia not described.

Of the remaining salts of zirconia, there have been more or less examined, the sulphite, selenate, borate, phosphate, gallate, oxalate, acetate, tartrate, benzoate, saclactate, citrate and malate; but these salts are not of sufficient importance to be noticed. The rest of the salts of zirconia, amounting to 46, are unknown.

General properties of the salts of zirconia.

The following circumstances are characteristic of the salts of zirconia.

1. They have an astringent taste, which is harsh and disagreeable.

2. They are decomposed by all the alkaline and earthy salifiable bases, zirconia being precipitated.

SECTION XIII.

SALTS OF THORINA.

Salts of thorina; what compounds.

SALTS OF THORINA are combinations of thorina with the different acids. But four of these compounds have been distinctly examined.

Hydrochlorate of thorina.

I. *Hydrochlorate of Thorina.*—Usual chemical name, *Muriate of Thorina.*—This salt may be formed by dissolving thorina in hydrochloric (muriatic) acid. It may be obtained in a syrupy mass, which does not deliquesce in the air, but dries and becomes white like enamel, by evaporating the solution in a moderate heat; but it cannot be made to crystallize.

Sulphate.

II. *Sulphate of Thorina.*—This salt may be formed by dissolving thorina in excess of sulphuric acid, and evaporating the solution obtained, until it forms crystals. It has a strong styptic taste, and is not altered by exposure to the air.

Nitrate.

III. *Nitrate of Thorina.*—This salt may be formed by dissolving thorina in nitric acid. The solution takes place very readily, unless the thorina has been previously exposed to a red heat; in which case, it is effected by long boiling only. The solution cannot be made to crystallize, but forms a mucilaginous mass, which becomes liquid by exposure to the air. It is converted, by evaporation in a moderate heat, into an opaque white mass similar to enamel, and in a great measure insoluble in water.

Carbonate.

IV. *Carbonate of Thorina.*—This salt is easily formed by precipitating an acid solution of thorina by carbonate of potash or of soda. Thorina seems to have considerable

affinity for carbonic acid. When newly precipitated, during the process of drying it attracts this acid from the air. Chap. IV.

What other salts this newly discovered salifiable base is capable of forming has not been ascertained.

The following circumstances are characteristic of the salts of thorina.

General properties of the salts of thorina.

1. They are precipitated by oxalate of ammonia.

2. When the nitrate or hydrochlorate of thorina is evaporated by a strong heat, it leaves, on the edges of the vessel employed, an opaque white film, which has the appearance of enamel.

SECTION XIV.

SALTS OF SILICA.

Salts of silica do not, strictly speaking, exist.

In consequence of the property, which hydrofluoric (fluoric) acid possesses, of dissolving glass or flint, it was formerly supposed that at least one salt of silica exists. More recent researches, however, have proved, that the combination of hydrofluoric (fluoric) acid and silica is not a salt, but a peculiar acid. In strict propriety, therefore, there is no such combination as a salt of silica. Silica is consequently not a salifiable base; but it has been classed as such, as giving it the most natural position, which it could assume in the arrangement adopted.

SECTION XV.

SALTS OF OXIDIZED IRON.

Salts of oxidized iron; what compounds.

Salts of Oxidized Iron are combinations of the protoxide or peroxide of iron with the different acids. The following are the most important of these salts.

Oxidized iron forms three salts with hydrochloric acid.

Hydrochloric acid forms one salt with each of the oxides of iron,* and a triple salt with the peroxide and ammonia.

1. Hydrochlorate of iron.

I. *Hydrochlorate of Iron.*—Usual chemical name, *Muriate of Iron.*—This salt may be formed by dissolving iron

* The reader has already had explained to him the meaning of the prefixes *proto* and *per*, as applied to oxides. It may now, very probably, be a matter of inquiry with him, how salts, containing different oxides of the same metal, are to be distinguished from each other. Dr. Thomson has adopted the plan of prefixing, to the salts themselves, the syllables, distinguishing the oxides which they

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filings in hydrochloric (muriatic) acid. The solution must be kept from the air, and, by evaporation, yields the salt in crystals. The salt has a pale-green colour, and is extremely soluble in water. Its solution attracts oxygen from the air, or from nitric acid, and the salt itself becomes converted into a perhydrochlorate (permuriate). Its solution also is capable of absorbing deutoxide of azote (nitrous gas) in large quantity; and when saturated, it acquires a dark-brown colour, and a much more astringent taste than the salt has in its usual state. When the salt is exposed to a red heat, it is decomposed, and converted into a protochloride of iron; water being at the same time formed.

II. PERHYDROCHLORATE OF IRON.

(Usual chemical name, *Permuriate of Iron.*)

2. Perhydrochlorate of iron.

1. This salt may be formed by dissolving peroxide of iron in hydrochloric (muriatic) acid, and evaporating the solution to dryness. It is an uncrystallizable, deliquescent, orange-coloured mass. In solution, it has a deep-brown colour, a peculiar odour, and, even when very much diluted, an exceedingly astringent taste. Like chlorine, it tinges animal and vegetable substances of a yellow colour. When distilled, it suffers decomposition; the hydrogen of the acid combines with a portion of the oxygen of the peroxide, reducing the latter to the state of protoxide, and forms water; while its chlorine passes over. When exposed to a red heat, water is formed and dissipated, and it is converted into a perchloride of iron.

Tincture of this salt;

2. The London colleges form a tincture of this salt, under the title of the *tincture of muriated iron.* They dissolve half a pound of percarbonate of iron (rust of iron) in three pounds of hydrochloric (muriatic) acid, and evaporate the solution, so as to form one pint of liquid, to which they add three pints of alcohol. The other colleges prepare a simple hydrochlorate (muriate) of iron for the formation of the tincture. But as it is very doubtful whether the simple hydrochlorate will dissolve in alcohol; and, if it will, as the fact is well ascertained that it is very liable, by exposure to air,

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may contain. This plan I proposed in a short paper, published in the Memoirs of the Columbian Chemical Society, in 1813; but I was not then aware that it had been adopted by Dr. Thomson. The plan, however, although original with myself, and sanctioned by the usage of this respectable chemist, upon further consideration, I propose to modify in the following manner: Whenever a protoxide is the base of a salt, which is by far most generally the case, I propose to employ no prefix; while, on the other hand, when a peroxide constitutes the base, the prefix *per* will always be retained. In this way, no possible ambiguity can arise; while, at the same time, many long and ungraceful appellations will be avoided.

to be converted into the perhydrochlorate, there is good reason to prefer the preparation of the London college. CHAP. IV.

3. Tincture of perhydrochlorate of iron has a yellowish colour and very astringent taste. It is a most excellent preparation of iron, and may be exhibited in doses of from ten to twenty drops, properly diluted, twice or thrice a day. employed in medicine.

III. PERHYDROCHLORATE OF AMMONIA-AND-IRON.

(Usual chemical name, *Muriate of Ammonia-and-Iron.*—Formerly called, *Martial Flowers—Ammoniacal Iron.*)

1. This salt may be formed by dissolving in water sixteen parts of hydrochlorate of ammonia (sal ammoniac) and one part of perhydrochlorate of iron, evaporating the solution to dryness, and subliming. It is directed by the Edinburgh college to be prepared by subliming, thoroughly mixed, peroxide of iron and hydrochlorate of ammonia. 3. Ammonio-perhydrochlorate.

2. When properly prepared, it has a deep-orange colour, and a smell resembling that of saffron. It is deliquescent in the air. For preservation, it must be kept in well-stopt phials.

3. When used as a medicine, it has the usual tonic properties of the preparations of iron. But when it is considered that the iron is united with two such powerful substances as the hydrochloric (muriatic) acid and ammonia, it is reasonable to suppose that its usual virtues are very considerably increased. This preparation certainly deserves more attention than is bestowed upon it by American physicians. Its dose is from two to ten grains. Dissolved in alcohol, it forms the tincture of ammoniacal iron of the London college. Medical properties.

Sulphuric acid forms one salt with protoxide of iron, and one salt with protoxide of iron and potash. Protoxide of iron enters into two sulphates.

IV. SULPHATE OF IRON.

(Syn. *Green Vitriol.—Copperas.—Vitriolated Iron.—Salt of Steel.*)

1. This salt is formed, in the large way, by moistening sulphuret of iron (pyrites), which is found native, in abundance, in different parts of the world, and exposing it to the air. Part of the sulphur is slowly converted into sulphuric acid, which, combining with the iron, forms a crust of this salt on the pyrites. This crust is then dissolved off by water, and the solution formed, evaporated for crystallization. 1. Sulphate of iron.

2. Sulphate of iron is in the form of crystals of a fine green colour. It has a strong styptic taste, and is capable of reddening vegetable blues. It is soluble in twice its weight of cold water, and in three-fourths of its weight of boiling water. When exposed to the air, it absorbs oxygen, gradually becomes opaque, and is covered with a yellow powder, being in part converted into the persulphate. When

Book I. Division II. heated, it gradually loses its water of crystallization, which amounts to about 45 per cent. In a strong heat, its acid is driven off, and a red powder remains behind, formerly called *colcothar of vitriol*. This residue is the peroxide of iron, generally mixed with some persulphate. When distilled, at first a portion of acidulous water is driven over, but afterwards, a very strong fuming acid, formerly called *glacial oil of vitriol*. The residuum in this case also is the peroxide.

3. Sulphate of iron is composed of

Sulphuric acid	40	—one atom.
Protoxide of iron	36	—one atom.

Giving 76 for the number representing the weight of its atom.

4. This salt, in the materia medica, is classed as an astringent. In small doses of from one to three grains, it may prove both tonic and astringent; but it is apt to excite pain in the stomach and bowels. In large doses, it causes vomiting.

2. Potasso-sulphate. V. *Sulphate of Potash-and-Iron.*—This salt may be formed by boiling iron filings in a solution of supersulphate of potash. It is in the form of efflorescent crystals, which resemble those of sulphate of iron (green vitriol).

Peroxide of iron enters into three sulphates. Sulphuric acid forms three salts by combining with peroxide of iron; namely, persulphate, subbipersulphate and tripersulphate of iron.

VI. *Persulphate of Iron.*—This salt is formed, when concentrated sulphuric acid is digested in a flask upon peroxide of iron. It has a white colour. By the addition of water, it is decomposed into a supersalt and a subsalt.

VII. *Subbipersulphate of Iron.*—This salt may be formed by dissolving crystallized sulphate of iron in water acidulated with nitric acid, evaporating the solution formed to dryness, and exposing the dry mass to a heat sufficient to drive off all the nitric acid. The sulphate is, in this way, converted into a persulphate. If water be poured upon this persalt, three-fourths of it are dissolved, and the one-fourth which is insoluble is the salt under description. It is a reddish-yellow powder, without either taste or smell. It is composed of

Sulphuric acid	40	—one atom.
Peroxide of iron	160	—two atoms.
	200*	

* The above analysis is given, in order to explain why Dr. Thomson calls this salt a subbipersulphate.—It is presumed, that, when a salt is composed of one

VIII. *Tripersulphate of Iron.*—The soluble portion of the persulphate, when treated with water, constitutes this salt. Its taste is intensely astringent and very harsh. When evaporated to dryness and exposed to the air, it deliquesces. It is incapable of crystallizing. It is composed of

Sulphuric acid 120—three atoms.
Peroxide of iron 80—one atom.

Giving 200 for the number representing the weight of its atom.

Nitric acid forms a salt with each of the oxides of iron.

Oxidized iron forms two salts with nitric acid.

IX. *Nitrate of Iron.*—This salt may be obtained in the form of solution by pouring nitric acid of the specific gravity of 1·16 upon iron. It acts upon the metal slowly without emitting any gas, and the solution at first is of a dark olive-brown colour, owing to deutoxide of azote (nitrous gas) being held in solution. But by exposure to air, the deutoxide of azote is converted into nitric acid by combining with oxygen, and the solution assumes a pale-green colour, and now contains nothing but nitrate of iron. It cannot be concentrated or heated without being converted into a pernitrate.

X. *Pernitrate of Iron.*—This salt may be formed by dissolving iron in strong nitric acid, or by exposing the nitrate to the air. It cannot be obtained in crystals without difficulty. It is usually in the state of a brown coloured solution, which, upon evaporation, lets fall a red powder, insoluble in nitric acid.

XI. CARBONATE OF IRON.

Carbonate of iron; how prepared.

1. This salt may be obtained, by double decomposition, from sulphate of iron and carbonate of potash or of soda. The Edinburgh college prefer the carbonate of soda; as the sulphate of soda, which then becomes formed with the carbonate, is more easily washed off, from its greater solubility, than the sulphate of potash. When thus prepared, it is called precipitated carbonate of iron. It may be prepared also by moistening pure iron filings with water, and exposing them to the air. The filings become oxidized at the expense of the water, and attract carbonic acid from the atmosphere.

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atom of each of its constituents, it is a neutral compound. But a salt may be composed of two atoms of either of its ingredients, combined with one atom of the other When the two atoms are of the acid, then the salt formed is a supersalt, and its composition is indicated by the prefix *bi;* but when a salt is composed of one atom of acid and two atoms of base, its composition would be ambiguous with this prefix merely; and as it is presumed to be a subsalt, or a salt with excess of base, the two syllables *sub bi* are prefixed, indicating that the extra atom belongs to the base and not to the acid.

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This preparation, however, should not be used in medicine, it being in every respect inferior to the precipitated carbonate.

2. The carbonate of iron in crystals has been found native. It is somewhat transparent, and has a greenish-yellow colour. It is brittle and easily reduced to powder.

3. Carbonate of iron, when newly precipitated, is of a greenish colour, by reason of its being in the state of a hydrate. When dried without the contact of air, it becomes black and is a simple carbonate; but if the air be not excluded during drying, the iron becomes peroxidized, the salt assumes a red colour, and is now a *percarbonate* (rust of iron), the state in which the carbonate is used in medicine.

Medical properties.

4. Percarbonate of iron constitutes one of the best preparations of iron, which can be employed in medicine. Its dose is from 5 to 20 grains. In all cases, it is best to give the preparations of iron in small and repeated doses.

Protoxide of iron enters into two phosphates.

Phosphoric acid forms one salt with protoxide of iron, and one salt with protoxide of iron and ammonia.

XII. *Phosphate of Iron.*—This salt may be formed, by double decomposition, from sulphate of iron and phosphate of potash. It is an insoluble powder of a permanent blue colour. It occurs native, constituting the colouring matter of the mineral called native Prussian blue, which is found in bogs; and also, in the form of small crystals, in Brazil and the Isle of France. It is partly transparent and partly opaque, possessing a light-blue colour.

XIII. *Phosphate of Iron-and-Ammonia.*—This salt is formed by precipitating the solution of phosphate of iron in nitric acid, by ammonia.

Peroxide of iron enters into two phosphates.

Phosphoric acid forms two salts with peroxide of iron; namely, perphosphate and subperphosphate of iron.

XIV. *Perphosphate of Iron.*—This salt may be formed, by double decomposition, from perhydrochlorate (permuriate) of iron and phosphate of potash or of soda. A white precipitate immediately falls, which consists of the salt in question. It is nearly insoluble in water, but dissolves in acids, from which it may be precipitated unchanged by means of ammonia.

XV. *Subperphosphate of Iron.*—When a solution of pure potash or soda is poured into the perphosphate of iron, this salt is precipitated in the form of a brownish-red powder, scarcely soluble in water or in acids.

Two arseniates of

XVI. *Arseniate and Perarseniate of Iron.*—Both these salts have been found native in Cornwall. They may be

formed, artificially, by double decomposition; the former, from arseniate of ammonia and sulphate of iron, the latter, from the same arseniate and the persulphate. Chap. IV. Iron found native.

XVII. *Chromate of Iron.*—This salt has been found native, mixed with a portion of alumina and silica, in France, in Siberia, and near Baltimore in the United States.

XVIII. *Tungstate of Iron.*—This salt may be formed by precipitating sulphate of iron by the tungstates. Combined with a portion of manganese, it occurs native, in different parts of the world, under the name of Wolfram.

XIX. *Hydrofluate of Iron.*—Usual chemical name, *Fluate of Iron.*—Hydrofluoric (fluoric) acid acts upon iron very slowly. This salt, however, may be easily obtained from hydrofluate of potash and sulphate of iron. It is a white tasteless insoluble powder.

Ferrocyanic acid combines with both oxides of iron, and forms ferrocyanate and perferrocyanate of iron. Oxidized iron enters into two ferrocyanates.

XX. *Ferrocyanate of Iron.*—When ferrocyanate of potash is dropped into a solution of sulphate of iron freed by boiling from atmospheric air, this salt precipitates in the form of a white powder. By exposure to air, it absorbs oxygen and is converted into perferrocyanate of iron, (Prussian blue). 1. Ferrocyanate.

XXI. PERFERROCYANATE OF IRON.

(Usual chemical name, *Prussiate of Iron.*—Commonly called, *Prussian Blue.*)

1. The method of forming this salt in the small way has already been given at page 234. The outline of the process followed by the manufacturers is this. Raspings of horns, clippings of skins and other animal substances are exposed, in covered vessels, to a low red heat, and thereby converted into a kind of charcoal. Thirty pounds of impure carbonate of potash are then mixed with ten pounds of this coal, and the mixture, ignited for twelve hours in an iron vessel. When the mixture has acquired a pasty consistence, it is poured out into vessels of water. Part of the mass dissolves; and the solution thus obtained is mixed with a solution of three parts of supersulphate of alumina-and-potash (alum), and one part of sulphate of iron. A precipitate immediately forms, which is green at first, but afterwards, by being washed with diluted hydrochloric (muriatic) acid, becomes of a beautiful blue colour. 2. Perferrocyanate or Prussian blue; how obtained by the manufacturer.

2. It is not easy to explain intelligibly the process for forming this salt, consistently with the new discoveries, which have been made respecting its constituents. It would Probable explanation of the process.

appear, however, that the animal substances, by being ignited with carbonate of potash, form a cyanodide of potash. These substances appear to be essential to the process, only by furnishing the necessary quantity of azote for the formation of the cyanogen. On the supposition that the ferrocyanic acid is a compound of hydrocyanic acid and iron, then the explanation of the formation of the salt would seem to be this: at the moment that the sulphate of iron is added to the cyanodide of potash, water is decomposed, and at the same time, a portion of the oxide of iron of the sulphate, deoxidized. The cyanogen of the cyanodide, after being converted into ferrocyanic acid by combining with the hydrogen of the decomposed water and the reduced iron of the sulphate, then unites to the unreduced portion of the oxide, previously converted to the state of peroxide, so as to form the perferrocyanate. After the perferrocyanate is separated, the remaining liquid is a solution of sulphate of potash. The supersulphate of alumina-and-potash (alum), which is employed, is for the purpose of diluting the colour. Hence the Prussian blue of commerce always contains a portion of alumina. It is washed with diluted hydrochloric acid, in order to dissolve away some oxide of iron which remains in excess.

Properties of the perferrocyanate.

3. Perferrocyanate of iron is in the form of a powder of a deep blue colour. It is insoluble in water, and scarcely dissolves in acids. It remains unaltered in the air. When decomposed by heat, cyanogen is driven off, and oxidized iron remains behind.

Pergallate of iron.

XXII. *Pergallate of Iron.*—This salt may be formed by dropping gallic acid into a peroxidized salt of iron. It is in the form of a black precipitate, very fine and light, and remaining a long time suspended. If a portion of mucilage or syrup be added to the water holding the black precipitate, it becomes permanently suspended, and constitutes the liquid called writing ink. Ink is generally made by adding a quantity of water to a mixture of powdered nut-galls and sulphate of iron of commerce. This sulphate is a mixture of the two sulphates of iron; and accordingly, only part of it is proper to produce the precipitate of pergallate of iron. The portion of the sulphate, containing the protoxide, is found to form with gallic acid, a combination, which is colourless, but which, by attracting oxygen from the air, soon becomes converted into a pergallate and turns black. These facts supply the reason why some inks, at first very pale, become afterwards quite black by exposure to air.

Chemical nature of writing ink.

XXIII. *Persuccinate of Iron.*—When succinate of soda is dropped into solutions of the persalts of oxidized iron, this

salt precipitates in the form of brownish-red flakes. Succinate of soda is therefore a very excellent test of the presence of peroxide of iron, in solutions. CHAP. IV.

Acetic acid forms a distinct salt with each of the oxides of iron. Oxidized iron forms two salts with acetic acid.

XXIV. *Acetate of Iron.*—This salt may be formed by dissolving sulphuret of iron in acetic acid. It is in the form of crystals of a green colour, and sweetish styptic taste.

XXV. *Peracetate of Iron.*—This salt may be prepared, either by mixing together sulphate of iron and acetate of lead (sugar of lead), and exposing the mixture to the air, or by dissolving iron in the impure acetic acid obtained by distilling wood. It is deliquescent, and cannot be made to crystallize. When evaporated, it assumes the form of a jelly. Its solution in water has a brownish-red colour. It is much employed by calico printers; it being the most easily decomposed of any of the persalts of oxidized iron. When prepared with alcohol, it forms the *tincture of acetated iron*, of the Dublin college.

Tartaric acid forms one salt with protoxide of iron, and one salt with protoxide of iron and potash. Protoxide of iron enters into two tartrates.

XXVI. *Tartrate of Iron.*—When tartaric acid is poured into a solution of sulphate of iron, and the mixture heated, this salt may be obtained in the form of crystals which are sparingly soluble in water. 1. Tartrate.

XXVII. TARTRATE OF POTASH-AND-IRON.

(Old names, *Chalybeated Tartar—Tartarized Iron.*)

1. This salt may be obtained by boiling a mixture of two parts of bitartrate of potash (cream of tartar), and one part of iron filings, previously made into a paste with water, in a sufficient quantity of this liquid. The extra atom of acid in the bitartrate becomes saturated with protoxide of iron. By proper evaporation, the salt may be obtained in crystals.—The Dublin college form this triple salt by boiling one part of carbonate of iron and two parts of bitartrate of potash, in thirty-two parts of water. The liquor thus obtained is filtered, and evaporated for crystallization. 2. Potasso-tartrate.

2. Tartrate of potash-and-iron is in the form of small needle-shaped crystals, possessing a chalybeate taste. It is very soluble in water.

3. When this salt is employed as a medicine, it acts as a tonic and aperient. From its chemical composition, there is reason to believe that it would be of service in many cases of chronic disease. It certainly deserves more atten- Its medical properties.

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tion than is generally paid to it by the medical profession in this country. Its dose is from 10 to 30 grains.

Chalybeate or ferrated wine may be considered as this triple salt dissolved in wine; since this liquid dissolves iron, only in consequence of the bitartrate of potash (tartar), which it contains. To make a uniform chalybeate wine, it would be preferable to dissolve a determinate quantity of the triple salt, ready formed, in some wine.

Peroxide of iron forms but one tartrate.

Tartaric acid forms but one salt with peroxide of iron.

XXVIII. *Pertartrate of Iron.*—When iron is dissolved in tartaric acid, and heat applied to the solution, this salt becomes formed. It has a red colour. It is not crystallizable by evaporation, but assumes the form of a jelly.

List of salts of oxidized iron not described.

Of the remaining salts of oxidized iron, there have been more or less examined by chemists, the sulphite, hyposulphite, hydrosulphate, selenate, borate, molybdate, antimoniate, sulphocyanate, purpurate, oxalate, benzoate, citrate, mellate, malate, lactate, suberate, zumate, and boletate; but these salts are of too little importance to be described. The rest of the salts of oxidized iron, amounting to 31, are unknown.

General properties of the salts of oxidized iron.

The salts of oxidized iron may be recognised by the following properties or marks.

1. The majority of them are soluble in water; and in general, they have a greenish or yellowish-red colour, and an astringent taste.

2. Ferrocyanate (triple prussiate) of potash, when dropped into their solutions, occasions a precipitate, which is either deep blue, or acquires this colour by exposure to the atmosphere. This precipitate is the perferrocyanate of iron (Prussian blue).

3. Phosphate of soda occasions a white precipitate in their solutions.

4. Succinate of ammonia precipitates the peroxidized salts of a flesh-colour, but has no effect upon the protoxidized salts.

SECTION XVI.

SALTS OF OXIDIZED NICKEL.

SALTS OF OXIDIZED NICKEL are combinations of the oxides of nickel with the different acids. Only three of these compounds will be noticed. Salts of oxidized nickel, what compounds.

I. *Hydrochlorate of Nickel.*—Usual chemical name, *Muriate of Nickel.*—When pure nickel is dissolved in hydrochloric acid assisted by nitric acid, and the solution evaporated, this salt is obtained in crystals of an apple-green colour. In the air, they at first deliquesce, but, by long exposure, suffer decomposition. When somewhat heated, the salt becomes yellow, and loses about 55 per cent. in water of crystallization; but its original quantity is restored again, when it is exposed to the air, by the absorption of moisture. In a stronger heat, it is decomposed. Hydrochlorate of nickel.

II. *Sulphate of Nickel.*—This salt may be formed by dissolving pure nickel in sulphuric acid, occasionally assisted by nitric acid. It is in the form of crystals, which have a beautiful green colour, and are not altered by exposure to the air. It has an astringent taste, and is very soluble in water. When heated, it swells without melting, and assumes a yellow colour, owing to the loss of its water of crystallization. Sulphate.

III. *Nitrate of Nickel.*—When nickel is dissolved in nitric acid by the assistance of heat, the solution, by evaporation, yields this salt in crystals. These crystals, by exposure to air, at first deliquesce, but afterwards fall to powder, and gradually lose their acid. Nitrate.

Of the remaining salts of oxidized nickel, there have been more or less examined by chemists, the ammonio-sulphate, potasso-sulphate, ferro-sulphate, selenate, ammonio-nitrate, carbonate, borate, phosphate, arseniate, chromate, molybdate, sulphocyanate, purpurate, oxalate, acetate and zumate; but these salts are of too little importance to be noticed. The rest of the salts of oxidized nickel, amounting to 48, are unknown. List of salts of oxidized nickel not described.

The salts of oxidized nickel may be recognised by the following properties or marks. General properties of the salts of oxidized nickel.

1. They are generally soluble in water; and their solutions have a beautiful green colour.

2. When ferrocyanate (triple prussiate) of potash is dropped into their solutions, a milk-white precipitate is formed.

3. Hydrosulphate (hydrosulphuret) of potash, occasions a black precipitate.

SECTION XVII.

SALTS OF OXIDIZED COBALT.

Salts of oxidized cobalt; what compounds.

SALTS OF OXIDIZED COBALT are combinations of the protoxide of cobalt with the different acids. The peroxide is not known as a salifiable base. Only four of these compounds will be noticed.

Hydrochlorate of cobalt.

I. *Hydrochlorate of Cobalt.*—Usual chemical name, *Muriate of Cobalt.*—This salt may be formed by dissolving cobalt in hydrochloric (muriatic) acid, assisted by nitric acid. The solution, when sufficiently concentrated, deposites small deliquescent crystals, which are at first blue, but afterwards become red by the absorption of moisture. This salt, when dissolved in water, forms one of the best sympathetic inks known. When the solution is very much diluted, it is nearly colourless; and if employed to trace letters on paper, the writing remains invisible in the cold; but if the paper be gently heated, the letters become visible of a fine green colour. When the salt is heated to redness in a retort, those portions of it, which are in contact with the vessel, undergo decomposition, tinging, at the same time, the glass of a blue colour; the rest melts, and afterwards sublimes in grey-coloured flowers, which are difficultly soluble in water.

Sulphate.

II. *Sulphate of Cobalt.*—When boiling sulphuric acid is digested upon cobalt, the metal is dissolved; and there is obtained a brownish-red mass, which, by solution and evaporation, yields this salt in small needle-form crystals. It has a reddish-colour, and is not altered by exposure to air. When heated, it loses 42 per cent. in water of crystallization, and becomes converted into an opaque, rose-coloured mass.

Nitrate.

III. *Nitrate of Cobalt.*—When nitric acid is digested upon cobalt with the assistance of heat, the solution obtained, by evaporation, yields this salt, in the form of crystals, which are deliquescent in the air, and suffer decomposition by heat.

IV. *Hydrofluate of Cobalt.*—Usual chemical name, *Fluate of Cobalt.*—This salt may be obtained by dissolving protoxide of cobalt in hydrofluoric (fluoric) acid, and evaporating the solution formed. It is in the form of small red crystals, which contain a small excess of acid. When treated with water, it is divided into two salts; a superhydrofluate which remains in solution, and a neutral hydrofluate which precipitates in the form of a red powder.

Of the remaining salts of oxidized cobalt, there have been more or less noticed by chemists, the selenate, ammonio-nitrate, carbonate, borate, phosphate, arseniate, antimoniate, antimonite, sulphocyanate, purpurate, oxalate, acetate, tartrate, and zumate. The rest of the salts of oxidized cobalt, amounting in number to 46, are unknown.

CHAP. IV.

List of salts of oxidized cobalt, not described.

The salts of oxidized cobalt may be recognised by the following properties or marks.

General properties of the salts of oxidized cobalt.

1. The greater number of them are soluble in water; and their solutions, when containing a neutral salt, have a reddish colour.

2. Potash or soda, when dropped into them, occasions a blue precipitate.

3. Ferrocyanate (triple prussiate) of potash occasions a yellowish-brown precipitate, often having a shade of blue.

SECTION XVIII.

SALTS OF OXIDIZED MANGANESE.

Salts of oxidized manganese; what compounds.

Salts of Oxidized Manganese are combinations of the protoxide and peroxide of manganese with the different acids: the deutoxide is not known to enter, as a constituent, into any salt. Four only of these salts will be noticed.

Hydrochlorate of manganese.

I. *Hydrochlorate of Manganese.*—Usual chemical name, *Muriate of Manganese.*—This salt may be formed by dissolving protoxide or carbonate of manganese in hydrochloric acid. It is difficult to obtain it in crystals. It is transparent, and has a rose-red colour, and a caustic taste, which leaves a saltish impression upon the tongue. It speedily deliquesces in the air. When exposed to heat, it undergoes the watery fusion; and if the temperature be increased to redness, the greater part of the acid is driven off.

Oxidized manganese forms two salts with sulphuric acid.

Sulphuric acid forms a salt with either the protoxide or peroxide of manganese.

II. *Sulphate of Manganese.*—This salt may be obtained by dissolving carbonate of manganese in sulphuric acid. It is formed also, when the peroxide is treated with sulphuric acid, with the assistance of heat. The oxide becomes reduced to the state of protoxide (oxygen being extricated in the gaseous form) and then dissolves in the acid. It is in the form of silky, needle-shaped crystals, of a sweetish taste. It is not altered by exposure to the air. After being

dried, it is soluble in about three times its weight of cold water.

III. *Persulphate of Manganese.*—This salt may be obtained by distilling sulphuric acid off the peroxide of manganese. A mass is thus obtained, which, by treatment with water, affords a violet-coloured liquor, holding this sulphate in solution. It cannot be obtained easily in crystals. When the solution is evaporated, it is converted into a jelly-like mass, intermixed with soft crystals of little permanency. When evaporated to dryness, it yields thin red-coloured crusts, which are formed by successive precipitations from the surface.

Nitrate of manganese.

IV. *Nitrate of Manganese.*—Nitric acid dissolves manganese with effervescence, owing to the formation of deutoxide of azote (nitrous gas). It acts with great difficulty upon the peroxide; but, after long digestion, the solution is effected. Its solvent power is greatly assisted by the addition of sugar or gum, as the solution is going on, and a quantity of carbonic acid is emitted. This circumstance shows, that part of the oxygen of the peroxide is yielded up to combine with the carbon of the substances added. The easiest method, however, for forming this salt, is to dissolve the carbonate in nitric acid, and to evaporate the solution cautiously. The salt is thus obtained in needle-form crystals, semi-transparent and of a white colour. It has a sharp bitter taste, and is soluble in water and deliquescent in the air.

List of salts of oxidized manganese omitted.

Besides the four salts just described, there have been more or less noticed by chemists, the hydrosulphate, seleniate, carbonate, phosphate, arseniate, chromate, tungstate, antimoniate, hydrofluate, sulphocyanate, oxalate, succinate, acetate, tartrate, potasso-tartrate, benzoate, citrate and zumate of manganese; but these salts are of too little importance to be described. The rest of the salts of oxidized manganese, amounting in number to 43, are unknown.

General properties of the salts of oxidized manganese.

The salts of oxidized manganese may be known by the following properties or marks.

1. Their solutions are precipitated, by the carbonate of potash or soda, of a white or reddish colour, becoming black by exposure to air. This precipitate is a carbonate of manganese.

2. Ferrocyanate (triple prussiate) of potash occasions a white precipitate.

3. Hydrosulphate (hydrosulphuret) of potash occasions a white precipitate.

SECTION XIX.

SALTS OF OXIDIZED CERIUM.

Salts of oxidized cerium; what compounds.

SALTS OF OXIDIZED CERIUM are combinations of the oxides of cerium with the different acids. Five only of these compounds will be noticed.

Hydrochloric acid combines with the peroxide of cerium only.

Perhydrochlorate of cerium.

I. *Perhydrochlorate of Cerium.*—Usual chemical name, *Muriate of Cerium.*—When peroxide of cerium is treated with hydrochloric acid, a solution is obtained, which, by concentration, may be made to yield this salt in crystals of a yellowish-white colour. It has an astringent and sweet taste, and deliquesces in the air. When exposed to heat, it is completely decomposed.

Oxidized cerium forms two sulphates;

Sulphuric acid forms a distinct salt with each of the oxides of cerium.

II. *Sulphate of Cerium.*—This salt may be formed by dissolving the protoxide or carbonate of cerium in sulphuric acid. The solution is colourless and has a sweet taste, and readily yields the salt in crystals.

III. *Persulphate of Cerium.*—By digesting peroxide of cerium, for some time, in diluted sulphuric acid, there is obtained an orange-coloured solution, which yields, by evaporation, this salt in needle-form crystals. Its colour is partly lemon-yellow and partly orange. It is not soluble in water, unless it contain an excess of acid; in which case its solution has an acid and sweet taste. When exposed to the air, it falls into a yellow powder.

and two nitrates.

Nitric acid forms a distinct salt with each of the oxides of cerium.

IV. *Nitrate of Cerium.*—When nitric acid is poured upon the protoxide or carbonate of cerium, this salt is readily obtained in solution. The solution, which is colourless and possesses an austere sweet taste, always retains an excess of acid, and cannot be made to crystallize without difficulty.

V. *Pernitrate of Cerium.*—When peroxide of cerium is dissolved in hot nitric acid, the solution yields this salt in small white crystals, which deliquesce when exposed to the air, and suffer decomposition by heat.

List of salts of oxidized

Of the remaining salts of oxidized cerium, the following have been noticed by chemists; namely, the potasso-sulphate,

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sulphite, selenate, carbonate, phosphate, arseniate, molybdate, oxalate, succinate, acetate, tartrate, benzoate and citrate. The rest of the salts of oxidized cerium, amounting in number to 48, are unknown.

cerium omitted.

General properties of the salts of oxidized cerium.

The salts of oxidized cerium may be distinguished by the following marks.

1. The protosalts are white, and the persalts, yellow.
2. Their solutions in water have a sweet taste.
3. Hydrosulphate (hydrosulphuret) of potash occasions a white precipitate, consisting of the protoxide.
4. Ferrocyanate (triple prussiate) of potash occasions a milk-white precipitate.

SECTION XX.

SALTS OF OXIDIZED URANIUM.

Salts of oxidized uranium; what compounds.

SALTS OF OXIDIZED URANIUM are combinations of the oxides of uranium with the different acids. Four of these salts only will be noticed.

Hydrochlorate of uranium.

I. *Hydrochlorate of Uranium.*—Usual chemical name, *Muriate of Uranium.*—Hydrochloric acid scarcely acts upon uranium in the metallic state, but dissolves the protoxide. The solution formed yields this salt in crystals, which have a yellowish colour, and are deliquescent in the air.

Sulphate.

II. *Sulphate of Uranium.*—Sulphuric acid, when cold, has very little action upon uranium; but when diluted and assisted by heat, it dissolves its protoxide, and the solution obtained yields needle-formed crystals of this sulphate. This salt has a lemon-yellow colour. It dissolves in somewhat more than half its weight of cold water, and in a less quantity of boiling water. When exposed to a red heat, its acid is entirely dissipated, and nothing remains but the pure protoxide.

Protoxide of uranium forms two nitrates.

Nitric acid forms a neutral salt and a subsalt with protoxide of uranium.

III. *Nitrate of Uranium.*—This salt may be formed by dissolving protoxide of uranium in nitric acid. It is in the form of lemon-yellow crystals, which are greenish on the edges; but if it contain an excess of acid, the crystals are entirely greenish. Cold water dissolves about twice its weight of this salt. Boiling water dissolves any quantity;

the water of crystallization being sufficient to effect the solution at the boiling temperature. When exposed to the air, heated to about the temperature of 100°, it very soon falls into a white powder; but in a cold and damp situation, it deliquesces, and is converted into a liquid.

IV. *Subnitrate of Uranium.*—This salt may be formed by heating nitrate of uranium, until it becomes of an orange-yellow colour, and then treating it with water. The portion of it, which remains undissolved, is the subnitrate. It is in the form of a powder of a lemon-yellow colour.

List of salts of oxidized uranium omitted.

Besides the four salts just described, there have been noticed, by different chemists, the selenate, phosphate, arseniate, molybdate, tungstate, sulphocyanate, acetate and tartrate of uranium; but these salts are of too little importance to be described. The rest of the salts of oxidized uranium, amounting to 52, are unknown.

General properties of the salts of oxidized uranium.

The salts of oxidized uranium may be distinguished by the following marks.

1. The greater number of them are soluble in water; and the solutions have a yellow colour.

2. Potash and soda, or their carbonates, occasion a white precipitate, which is soluble in excess of these salifiable bases.

3. Ferrocyanate (triple prussiate) of potash occasions a brownish-red precipitate, which is not in the form of flakes.

4. Hydrosulphate (hydrosulphuret) of potash occasions a brownish-yellow precipitate.

SECTION XXI.

SALTS OF OXIDIZED ZINC.

Salts of oxidized zinc; what compounds.

Salts of Oxidized Zinc are combinations of the oxide of zinc with the different acids. The following are the most important of these salts.

Chlorate of zinc.

I. *Chlorate of Zinc.*—Former chemical name, *Hyperoxymuriate of Zinc.*—Chloric acid dissolves zinc without effervescence, and the solution contains both chlorate and chloride of zinc. Hence, it is evident, that part of the acid is decomposed; the oxygen of the decomposed portion oxidizes a part of the zinc, with which the undecomposed portion combines in the form of chlorate of zinc; while its chlorine forms a chloride with the metallic zinc. This salt, however, may be obtained, in a separate state, by dissolv-

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ing carbonate of zinc in chloric acid, and evaporating the solution until it crystallizes. It has a very astringent taste. On burning coals, it fuses and produces a yellow light, but does not detonate.

Hydrochlorate of zinc.

II. *Hydrochlorate of Zinc.*—Usual chemical name, *Muriate of Zinc.*—This salt may be formed by dissolving zinc in hydrochloric acid. The solution is attended with effervescence, owing to the extrication of hydrogen gas. When evaporated, it does not crystallize, but forms a mass resembling jelly. When distilled, a portion of its acid separates, and a solid mass is left behind, which is very soluble in water, and attracts moisture from the air, so as to assume a gelatinous consistency. When evaporated to dryness, and afterwards exposed to a red heat in a glass vessel with a narrow orifice, it is converted into chloride of zinc.

III. *Iodate of Zinc.*—This salt may be obtained by dissolving carbonate of zinc in iodic acid. After an interval of a few hours, the salt precipitates in spherical grains. It is but sparingly soluble in water.

IV. *Hydriodate of Zinc.*—This salt may be formed by heating iodine, with excess of zinc, under water. The water at first acquires a deep-brown colour; but afterwards, if the heat be continued, it becomes colourless. It now constitutes a solution of this hydriodate. It cannot be made to crystallize. When evaporated to dryness and fused, it is converted into a crystallized iodide of zinc.

V. SULPHATE OF ZINC.

(Common names, *Vitriolated Zinc.*—*White Vitriol.*)

Sulphate of zinc; how obtained.

1. This salt may be formed by dissolving three parts of zinc filings in five parts of sulphuric acid, previously diluted with twenty parts of water. The solution, on being set aside, deposites the sulphate in crystals.

2. It is prepared by the manufacturer by roasting native sulphuret of zinc (blende). By this measure, the sulphur becomes acidified, and the metal, converted into an oxide. The mineral, thus altered, is then dissolved in water, and the solution obtained, concentrated so far as that the sulphate suddenly crystallizes in a mass, not unlike white sugar. In this state, it constitutes the *white vitriol* of commerce. It is, however, impure, owing to admixture of iron, copper and lead. Apothecaries very frequently put up, in prescriptions, the impure sulphate of commerce; but, before being used medicinally, it ought always to be purified by solution, and mixture with a quantity of zinc filings. Zinc has the property of precipitating all metals from their solutions; and hence its use in the purification, as it throws

down all the foreign metals, and takes their place. The impure sulphate may be distinguished by its having yellow spots, and by letting fall, upon solution, a dirty brown sediment.

3. This salt was discovered in Germany about the middle of the sixteenth century. It was first proved to contain zinc by Henkel and Newmann; but it was Brandt, who ascertained its composition completely.

Properties.

4. Sulphate of zinc has a white colour, and a metallic styptic taste. It dissolves in about two-thirds of its weight of cold water, and to any amount in boiling water. Its specific gravity, when in the form of crystals, is 1·912; but, in an impure state as it occurs in commerce, it is 1·327. When exposed to heat, it speedily melts, then loses its water of crystallization, amounting to about 36 per cent. and at last, when the temperature is considerably raised, it parts with the greater portion of its acid.

5. It is composed of

Sulphuric acid	40	—one atom.
Oxide of zinc	41	—one atom.
	81	

Giving 81 for the number representing the weight of its atom.

Uses in medicine.

6. Sulphate of zinc is frequently used in medicine, and with various intentions. When employed in small doses, it is said to act as a tonic. In doses of from ten grains to half a drachm, it acts as a very prompt emetic, and on this account is generally preferred for the purpose of dislodging poison from the stomach. When given with this view, it may be exhibited, in urgent cases, in very large doses. In solution, it is frequently used as an injection in gonorrhœa, to act as a sedative and astringent application. It forms a part of the most efficacious astringent collyria. In solution, along with supersulphate of alumina-and-potash (alum), it forms the compound alum water of the London college, formerly called Bates's alum water, which is frequently used for the purpose of cleansing ulcers, and as a wash for cutaneous eruptions.

Nitrate of zinc.

VI. *Nitrate of Zinc.*—This salt may be formed by dissolving zinc in nitric acid. The acid acts upon the metal with great energy, and large quantities of deutoxide of azote (nitrous gas) are emitted. The solution is transparent and colourless, and possesses a styptic taste. When sufficiently evaporated, it yields the nitrate in crystals. This salt is soluble in water, and deliquescent in the air. When heated on burning coals, it first melts, and then detonates with a red flame. In a strong heat, it is completely

decomposed, its acid being converted into deutoxide of azote and oxygen gas.

VII. CARBONATE OF ZINC.

(Common name, *Calamine.*)

Carbonate of zinc.

1. This salt may be formed by precipitating a solution of any salt of zinc, by means of the carbonate of potash or of soda.

How prepared for use in medicine.

2. For the purposes of medicine, it is prepared from calamine, a native carbonate of zinc, found abundantly in England, Germany, and other countries, by a process similar to that for forming prepared carbonate of lime (chalk). The native carbonate has a variety of colours; the most usual are greyish, brownish, yellowish, or pale reddish. Its hardness is considerable. Before the blow-pipe, it decrepitates and sublimes. It dissolves in many of the acids with effervescence.

3. It is composed of

Carbonic acid 22—one atom.
Oxide of zinc 41—one atom.

Giving 63 for the number representing the weight of its atom.

Medical properties.

4. This salt is used in medicine as an external application only. It is employed in collyria for defluctions from the eyes, and as a drying application for moist running ulcers, and excoriations. It is usually applied in the form of a cerate. This cerate is called epulotic cerate. It is essentially the same with Turner's cerate.

VIII. *Hydrofluate of Zinc.*—Usual chemical name, *Fluate of Zinc.*—This salt may be obtained by dissolving zinc in diluted hydrofluoric acid; or by precipitating sulphate of zinc by means of hydrofluate of potash. It is a white, tasteless, insoluble powder.

IX. ACETATE OF ZINC.

Acetate of zinc; how obtained.

1. This salt may be formed by dissolving zinc in acetic acid; or by mixing together the solutions of sulphate of zinc (white vitriol), and acetate of lead (sugar of lead). When obtained by the latter method, a double decomposition takes place; and an insoluble sulphate of lead precipitates, while the acetate of zinc remains in solution. Whenever these two salts are prescribed in solution together, this double decomposition takes place; and an acetate of zinc becomes formed. But this is not a good way to prescribe the acetate; as, in many cases, ignorant patients will shake the liquid, which contains it, in order to diffuse the

insoluble sulphate, which appears as a sediment, at the bottom of the vial, under the impression that it may be a useful part of the medicine. The acetate, therefore, should always be ready prepared in the apothecaries' shops. It is easily formed by mixing the solutions of sulphate of zinc and acetate of lead together, and filtering the liquid obtained to separate the insoluble sulphate.

Properties.

2. Acetate of zinc may be obtained in crystals by evaporating its solution. It has a bitter metallic taste, and is very soluble in water. In the air, it suffers no alteration. When thrown upon live coals, it burns with a blue flame. When distilled, it yields water, an inflammable liquid, and some oil, and towards the end of the operation, the oxide of zinc sublimes.

Medical uses.

3. This salt is very much used, in solution, as an injection in gonorrhœa. It appears to be one of the best metallic preparations, which can be employed for abating inflammation. It is ordered by the Dublin college to be dissolved in alcohol; under which form, it is called the tincture of acetate of zinc. When thus prepared, it is used as a stimulating collyrium and injection.

List of salts of oxidized zinc, omitted.

Of the remaining salts of oxidized zinc, there have been more or less examined by chemists, the ferro-sulphate, cobalto-sulphate, sulphite, hyposulphite, hydrosulphate, selenate, borate, phosphate, arseniate, chromate, molybdate, tungstate, antimoniate, sulphocyanate, purpurate, oxalate, succinate, tartrate, potasso-tartrate, benzoate, citrate, malate, lactate, and zumate; but these salts are not of sufficient importance to be described. The rest of the salts, formed by this metallic oxide, amounting in number to 33, are unknown.

General properties of the salts of oxidized zinc.

The salts of oxidized zinc may be known by the following properties or marks.

1. The greater number of them are soluble in water, and their solutions are transparent and colourless.

2. Hydrosulphate (hydrosulphuret) of potash occasions a white precipitate, when dropped into them.

3. Ferrocyanate (triple prussiate) of potash occasions a white precipitate.

4. They afford no metallic precipitate, by metals, suspended in their solutions.

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SECTION XXII.

SALTS OF OXIDIZED LEAD.

Salts of oxidized lead; what compounds.

SALTS OF OXIDIZED LEAD are combinations of the protoxide of lead with the different acids. The peroxide is not known to combine with any acid: hence, strictly speaking, it is not a salifiable base. The following are the most important of these salts.

Chlorate of lead.

I. *Chlorate of Lead.*—Former chemical name, *Hyperoxymuriate of Lead.*—This salt may be formed by dissolving the semi-vitrified oxide of lead (litharge) in chloric acid. The solution has a very sweet astringent taste. By spontaneous evaporation, it deposites the chlorate in brilliant crystals. On burning coals, it emits a white smoke and the lead is revived.

Protoxide of lead enters into two hydrochlorates.

Hydrochloric acid forms a hydrochlorate and a subhydrochlorate by combining with protoxide of lead.

II. *Hydrochlorate of Lead.*—Usual chemical name, *Muriate of Lead.*—This salt may be formed by decomposing nitrate of lead by means of hydrochloric acid. It precipitates in the form of a white powder, which has a sweetish taste, and is soluble in twenty two parts of cold water. When dissolved in boiling water, it deposites, as the solution cools, in crystals of a white colour, and brilliant appearance like satin. These crystals are not altered by exposure to the air; but when heated, they melt and are converted into chloride of lead (horn lead). This salt is composed of

Hydrochloric acid 37—one atom.
Protoxide of lead 112—one atom.

Giving 149 for the number representing the weight of its atom.

III. *Subhydrochlorate of Lead.*—Usual chemical name, *Submuriate of Lead.*—This salt may be formed by treating, with water, a mixture of one part of semi-vitrified oxide of lead (litharge) and four parts of chloride of sodium (common salt). This process constitutes one of the methods for obtaining carbonate of soda from chloride of sodium (common salt); and it has been described and explained under the head of carbonate of soda. Subhydrochlorate of lead is insoluble in water, and when newly formed has a white colour. After exposure to heat, by the action of which it becomes of a fine yellow colour, it is employed as a paint.

Sulphate of lead.

IV. *Sulphate of Lead.*—Sulphuric acid, when cold, has little action upon lead; but in a boiling heat, it oxidizes and

dissolves this metal, sulphurous acid being at the same time emitted, and forms with it a thick white mass, consisting of this sulphate. This salt, however, may be more readily formed by precipitating acetate of lead by the sulphate of potash or of soda. It is a tasteless white powder. It occurs native in the form of crystals. It is composed of

Sulphuric acid	40—one atom.
Protoxide of lead	112—one atom.

Giving 152 for the number representing the weight of its atom.

Nitric acid forms a nitrate and a subnitrate by combining with protoxide of lead. Protoxide of lead forms two nitrates.

V. *Nitrate of Lead.*—This salt may be formed by dissolving lead or its carbonate in nitric acid. It is in the form of crystals, which are opaque and white, and have a silvery lustre. It has a sweetish and harsh taste, and is not altered by exposure to air. It is soluble in water. When exposed to heat, it decrepitates, undergoes a kind of detonation, and emits brilliant sparks. It is composed of

Nitric acid	54—one atom.
Protoxide of lead	112—one atom.

Giving 166 for the number representing the weight of its atom.

VI. *Subnitrate of Lead.*—This salt may be obtained by boiling a solution of nitrate of lead upon protoxide of lead, and filtrating the liquid formed while hot; upon its cooling, the subnitrate is deposited in pearl-coloured crystals, which have a sweet astringent taste.

VII. CARBONATE OF LEAD.

(Common names, *White Lead—Ceruse.*)

1. This salt may be obtained by precipitating a solution of lead in nitric acid, by means of the carbonate of potash or of soda. For the purposes of the arts, it is prepared by exposing thin plates of lead, rolled spirally and placed on their edges, to hot vapours of common acetic acid (vinegar). The plates, after a certain time, become covered with a white crust, which is scraped off. They are again and again exposed to the vapour of the acid, until they are entirely corroded. The white substance thus formed is carbonate of lead. The carbonic acid is probably formed by the decomposition of the acetic acid. Carbonate of lead; how prepared.

2. The carbonate of lead has been considered to be an oxide; and accordingly, the Edinburgh college calls it the white oxide of lead. It has also been called a subacetate of

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lead, on account of the manner in which it is prepared, it being by the action of common acetic acid (vinegar); but it is in fact a carbonate of lead, as was first ascertained by Bergman.

3. Carbonate of lead occurs native, sometimes in the form of crystals having a white colour and considerable lustre. Its specific gravity in this state is 7·23.

4. Carbonate of lead, when artificially formed, is a brittle, friable, heavy substance, insoluble in water, and possessing a snow-white colour and sweet taste. The beauty of its colour depends principally upon the purity of the lead from which it is manufactured. It has a scaly and foliated texture.

5. It is composed of

Carbonic acid	22—one atom.
Protoxide of lead	112—one atom.

Giving 134 for the number representing the weight of its atom.

Used in the arts and in medicine.

6. Carbonate of lead is very much employed in the arts as a white paint. In pharmacy, it is used in the composition of certain plasters and ointments, which are supposed to be efficacious as drying applications.

Chromate of lead.

VIII. *Chromate of Lead.*—When the solutions of nitrate of lead and chromate of potash or of soda are mixed together, this salt precipitates in the form of a powder. It constitutes a very important yellow pigment, under the name of chromic yellow. It is manufactured in the United States by decomposing the native chromate of iron, by means of potash, and precipitating the chromate of potash, thereby formed, by means of nitrate of lead. Chromate of lead occurs native under the name of the red lead ore of Siberia. In this state, it is in the form of crystals of a red colour, with a shade of yellow.

Hydrofluate.

IX. *Hydrofluate of Lead.*—Usual chemical name, *Fluate of Lead.*—Hydrofluoric acid has no sensible action upon lead. Hence vessels of lead are generally used to contain this acid, instead of glass ones, which are corroded by its action. This salt, however, may be formed by dropping hydrofluoric acid into acetate of lead. It is in the form of brilliant plates, which are insoluble in water, but dissolve in nitric, hydrochloric and hydrofluoric acids. When heated to redness, it melts, becomes yellow, and loses a portion of its acid.

Acetic acid combines in two proportions with protoxide of lead, and forms acetate and subacetate of lead. CHAP. IV. Protoxide of lead forms two acetates.

X. ACETATE OF LEAD.

Syn. *Sugar of Lead.—Sugar of Saturn.—Acetated Ceruse.*

1. There are two processes for manufacturing acetate of lead. One consists in dissolving carbonate of lead, prepared by exposing the metal to the fumes of vinegar, or the semi-vitrified oxide of lead (litharge), in acetic acid, and evaporating the solution until it crystallizes. The other method is to immerse thin plates of lead in acetic acid; and as those which are nearest the surface become incrusted with a coat of oxide, to place them near the bottom, and thereby to bring other plates to the surface, to be incrusted in their turn. These plates also are transferred to the bottom; and by being changed in this manner every day, the whole at last become dissolved. The solution obtained is then crystallized by evaporation. 1. Acetate of lead; how prepared.

2. Acetate of lead is in the form of white needle-shaped crystals, which have a glossy appearance. It has a sweet and somewhat astringent taste. Its specific gravity is 2·345. It dissolves in rather less than four times its weight of cold water, and in a somewhat smaller proportion of boiling water. In the air, it undergoes no change. It is affected by the light; and when exposed to heat, its acid is entirely decomposed. It is composed of Its properties.

Acetic acid	51—one atom.
Protoxide of lead	112—one atom.
	163

Giving 163 for the number representing the weight of its atom.

3. This salt constitutes a very active article of the materia medica. It appears to exert a very powerful influence over hæmorrhagies of the active kind. It acts in many alarming cases of this nature with wonderful promptitude. When the case is urgent and cannot admit of delay, the salt may be given in doses of from five to twenty grains, frequently repeated, or even in larger quantities. The danger of its exhibition, in large doses, appears to have been very much overrated. It is in very general use as an external application to abate inflammation. It is applied in solution by cloths or by means of crumbs of bread, or in substance, combined with cerate in the form of an ointment, formerly called *saturnine ointment*. Uses in medicine.

XI. SUBACETATE OF LEAD.

1. This salt may be formed by boiling together, in water, 100 parts of acetate of lead, and 150 parts of dry semi-vitrified oxide of lead (litharge), deprived of its carbonic acid. It is in 2. Subacetate of lead;

the form of crystalline plates. It is not so sweet as the acetate, or so soluble in water. The preparation, formed by boiling acetic acid (distilled vinegar) upon semi-vitrified oxide of lead as long as the latter is dissolved, is a solution of subacetate of lead. It was first made by Goulard, a surgeon of Montpelier, and recommended by him as an excellent application in inflammation. It was formerly distinguished by the names of *Goulard's extract*, and *vinegar of lead;* and is the same with the *water of acetated litharge* of the London college. When formed into a cerate with yellow wax and olive oil, with the addition of a little camphor, it constitutes the preparation well known by the name of Goulard's cerate, the *compound cerate of acetated litharge* of the London college.

the same as Goulard's extract of lead.

Medical uses.

2. Subacetate of lead had once considerable reputation as an abater of inflammation; but, at the present day, it is not considered to possess any advantages over the solution of the simple acetate, as an application in such cases.

List of salts of oxidized lead omitted.

Of the remaining salts of oxidized lead, there have been more or less examined by chemists, the sulphite, selenate, tellurate, nitrite, borate, phosphate, nitrophosphate, phosphite, arseniate, molybdate, tungstate, antimoniate, antimonite, sulphocyanate, purpurate, gallate, formate, oxalate, sorbate, succinate, tartrate, potasso-tartrate, benzoate, saclactate, citrate, mellate, malate, lactate, suberate and zumate; but these salts are not of sufficient importance to be noticed. The rest of the salts of oxidized lead, amounting in number to 27, are unknown.

General properties of the salts of oxidized lead.

The salts of oxidized lead may be known by the following properties or marks.

1. A considerable number of them are scarcely soluble in water, without an excess of acid. Those which are soluble, form solutions, which are generally colourless and transparent.

2. They have all, more or less, a sweet taste, accompanied with a degree of astringency.

3. Ferrocyanate (triple prussiate) of potash occasions a white precipitate in their solutions.

4. Hydrosulphate (hydrosulphuret) of potash occasions a black precipitate.

SECTION XXIII.

SALTS OF OXIDIZED TIN.

SALTS OF OXIDIZED TIN are combinations of the oxides of tin with the different acids. Salts of oxidized tin; what compounds.

Hydrochloric acid forms a distinct salt with each of the oxides of tin. Oxidized tin forms two salts with hydrochloric acid.

I. *Hydrochlorate of Tin.*—Usual chemical name, *Muriate of Tin.*—When tin is dissolved in four times its weight of hydrochloric acid, the brownish-yellow solution formed yields, upon evaporation, this salt in needle-shaped crystals, which are soluble in water, and somewhat deliquescent in the air. When treated with water, it is converted into a subsalt which precipitates, and a supersalt which remains in solution. When evaporated to dryness and afterwards fused in close vessels, water becomes formed, and the salt is converted into protochloride of tin. 1. Hydrochlorate of tin.

II. *Perhydrochlorate of Tin.*—Usual chemical name, *Permuriate of Tin.*—The hydrochlorate is very liable to be converted into this salt. It abstracts an atom of oxygen from a great number of bodies containing this supporter, and thereby has its protoxide converted into peroxide. This change is produced by the contact of air, and by the addition of nitric acid. It is effected also by arsenious and arsenic acid, which become reduced to the metallic state. When molybdic or tungstic acid is dropped into a solution of the simple hydrochlorate, the former becomes converted into molybdous acid, and the latter, into oxide of tungsten. The persalts of oxidized iron and of copper are reduced to protosalts, by being added to the same solution; while, under the same circumstances, antimonious acid, the oxide of zinc and silver, and the peroxide of mercury and manganese, are reduced to the metallic state. 2. Perhydrochlorate.

In all the chemical changes just enumerated, there is formed a perhydrochlorate of tin. This salt is an important agent in the production of the scarlet dye. When concentrated, and distilled with sulphuric acid by means of a gentle heat, it is converted into perchloride of tin (fuming liquor of Libavius).

Sulphuric acid forms a distinct salt with each of the oxides of tin. Oxidized tin forms two salts with sulphuric acid.

III. *Sulphate of Tin.*—This salt may be formed by pouring sulphuric acid into hydrochlorate of tin. It is in the form of a white powder, which may be crystallized by solution and evaporation.

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IV. *Persulphate of Tin.*—Sulphuric acid, when cold, has very little action on tin; but when assisted by heat, it first peroxidizes this metal, and then dissolves it. The solution obtained cannot be made to crystallize; but when evaporated, it assumes the form of a gelatinous mass, which deposites a white powder when treated with water.

Oxidized tin enters into two nitrates.

Nitric acid forms one salt with protoxide of tin, and one salt with peroxide of tin and ammonia.

V. *Nitrate of Tin.*—Nitric acid acts with great energy upon tin; a great deal of heat is evolved, and the metal becomes oxidized. When nitric acid, of the specific gravity of 1·114, is poured upon tin, a yellow coloured solution is obtained consisting of this salt. If water be added to this solution, the salt becomes decomposed, and protoxide of tin precipitates in the form of a powder. During the solution of the tin, a quantity of ammonia is formed. From this fact, it is evident, that both water and the acid are decomposed, and yield oxygen to oxidize the tin; while the hydrogen of the former, by combining with the azote of the latter, forms ammonia. The ammonia may be made sensible by its odour, upon the addition of potash to the solution.

VI. *Ammonio-pernitrate of Tin.*—When nitric acid, of the specific gravity of 1·25, is poured upon tin, a violent action takes place, the metal becomes peroxidized, but does not dissolve. Hence there is no pernitrate of tin. But a quantity of ammonia becomes formed, in the manner just explained, which is capable of combining with nitric acid and peroxide of tin, so as to form the triple salt here noticed. Whenever nitric acid appears to dissolve the peroxide of tin, it is by the assistance of ammonia, and the result is the formation of this triple salt.

Perhydrofluate.

VII. *Perhydrofluate of Tin.*—Usual chemical name, *Fluate of Tin.*—Hydrofluoric acid does not act upon metallic tin. This salt, however, may be formed by dissolving peroxide of tin in hydrofluoric acid. The solution, by evaporation, becomes opaque from the precipitation of the salt, which may be again dissolved by the addition of water.

List of salts of oxidized tin omitted.

Of the remaining salts of oxidized tin, there have been more or less examined by chemists, the sulphite, hydrosulphate, selenate, borate, phosphate, arseniate, sulphocyanate, purpurate, oxalate, succinate, acetate, tartrate, potasso-tartrate, benzoate and zumate; but these salts are of too little importance to be noticed. The rest of the salts of oxidized tin, amounting to 43, are unknown.

The salts of oxidized tin may be known by the following properties or marks.

General properties of the salts of oxidized tin.

1. They are generally soluble in water, and their solutions have usually a yellowish or brownish tinge. Sometimes, however, they are colourless.

2. Ferrocyanate (triple prussiate) of potash occasions a white precipitate when dropped into their solutions.

3. Hydrosulphate (hydrosulphuret) of potash occasions a brownish-black precipitate in solutions of the protosalts, and a golden yellow precipitate in solutions of the persalts.

SECTION XXIV.

SALTS OF OXIDIZED COPPER.

Salts of oxidized copper; what compounds.

Salts of Oxidized Copper are combinations of the peroxide of copper with the different acids. The protoxide of copper is not known to enter into the composition of any salt as a base. Hence all the salts to be enumerated in this section are persalts. The following are the most important of them.

Perchlorate of copper.

I. *Perchlorate of Copper.*—Former chemical name, *Hyperoxymuriate of Copper.*—This salt may be formed by dissolving peroxide of copper in chloric acid. It has a green colour. When exposed to heat, it fuses and gives out a green light. It cannot be crystallized without difficulty.

Perhydrochlorate.

II. *Perhydrochlorate of Copper.*—Usual chemical name, *Muriate of Copper.*—This salt may be formed by dissolving copper in hydrochloric acid assisted by heat, or its peroxide in the cold acid. The solution has a fine green colour, and may be made to yield crystals by concentration. This salt has a fine grass-green colour, and an exceedingly acrid and caustic taste. It is very soluble in water. By exposure to air, it attracts moisture, and is converted into an oil-like liquid. When evaporated to dryness, at a temperature not exceeding 400°, it is converted into perchloride of copper. If the heat be further increased, a portion of chlorine is driven off, and the perchloride becomes converted into a protochloride.

The compound, first formed by Proust, and heretofore considered a simple hydrochlorate (muriate) of copper, turns out, upon further examination, to be a protochloride of copper.

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Sulphuric acid forms three salts with peroxide of copper, and two salts with peroxide of copper and ammonia.

Peroxide of copper enters into five sulphates.

III. BIPERSULPHATE OF COPPER.

(Common names, *Vitriolated Copper—Blue Vitriol.*)

1. Bipersulphate of copper.

1. This salt is very seldom formed by the direct combination of its constituents. It is manufactured, in the large way, by evaporating and crystallizing mineral waters, containing the salt in solution; or by burning the native sulphuret of copper, or moistening it with water, and exposing it to the air. When formed by the latter methods, the sulphur becomes acidified, and the copper, oxidized; and, by their combination thus altered, they form the salt in question.

Properties.

2. Bipersulphate of copper is in the form of crystals, which have a deep blue colour, and a strong, styptic, metallic taste. It changes vegetable blues to red. Its specific gravity is 2·19. It is soluble in about four parts of cold water, and in one and a half parts of boiling water. When exposed to the air, it undergoes a slight efflorescence, and its surface becomes covered with a greenish-white powder. When heated, it loses its water of crystallization, which amounts to about 36 per cent. and becomes converted into a bluish-white powder. In a pretty strong heat, its acid is entirely driven off, and peroxide of copper remains behind.

3. It is composed of

Sulphuric acid	80	—two atoms.
Peroxide of copper	80	—one atom.
	160	

Hence it is evidently a bipersulphate.

Uses in medicine.

4. Bipersulphate of copper, even in small doses, proves powerfully and promptly emetic. But its internal use, owing to its activity, is not safe; and accordingly, it is not much employed. Externally, it is used, as an escharotic, to destroy warts and fungous excrescences; and as a stimulating application to indolent and ill-conditioned ulcers.

2. Persulphate.

IV. *Persulphate of Copper.*—This salt resembles very much the one last described. It is formed by saturating the extra atom of acid, contained in the bipersulphate, with peroxide of copper.

3. Subpersulphate.

V. *Subpersulphate of Copper.*—When a solution of pure potash is poured into a solution of the persulphate of copper, the potash abstracts a portion of sulphuric acid from the persulphate, and this salt appears in the form of a green powder, which swims on the surface of the solution.

4. Ammonio-persulphate.

VI. *Ammonio-persulphate of Copper.*—This salt has been formed by Berzelius. It is a compound of one atom of sulphate of ammonia, and one atom of persulphate of copper.

VII. AMMONIO-SUBPERSULPHATE OF COPPER.

(Formerly called, *Ammoniacal Copper.*)

1. This triple salt may be formed by pouring ammonia into a solution of bipersulphate of copper (blue vitriol), and afterwards adding alcohol (pure spirit of wine) to the blue liquid obtained. The alcohol has a stronger affinity for water than the triple salt has, which is in solution; hence the latter separates in the form of blue silky crystals. 5. Ammonio-subpersulphate.

2. It is prepared, by the apothecaries, by rubbing together, in a mortar, until all effervescence ceases, a mixture of bipersulphate of copper (blue vitriol) and carbonate of ammonia. The mixture becomes moist, in consequence of the triple salt formed containing less water of crystallization than its constituents in a separate state. It is then dried and preserved in well stopt vials. As it is liable to partial decomposition during its exsiccation, it is much preferable to prepare the salt by the method given in the foregoing paragraph.

3. This salt has been used in the treatment of epilepsy. But its doubtful efficacy, and the disagreeable effects, which it sometimes produces, have been the cause of its being in a great measure laid aside. The dose is about half a grain, exhibited twice a-day, and gradually increased. Medical uses.

Nitric acid combines in two proportions with peroxide of copper, and forms pernitrate and subpernitrate of copper. Peroxide of copper forms two salts with nitric acid.

VIII. *Pernitrate of Copper.*—This salt may be formed by dissolving copper in nitric acid, and slowly evaporating the solution until it crystallizes. The solution is attended with effervescence, owing to the emission of deutoxide of azote (nitrous gas). This salt is in the form of crystals, which have a fine blue colour, and an acrid and metallic taste. It is exceedingly caustic, and acts upon the skin with great energy. It is very soluble in water, and deliquescent in the air. At a heat, not exceeding 100°, it undergoes the watery fusion; and, if the temperature be increased, loses its water, and ultimately a part of its acid. It acts with great energy upon tin; and if a portion of it be moistened with water and wrapt up in a sheet of tinfoil, a strong heat is produced, a quantity of deutoxide of azote is quickly formed, and the tinfoil bursts open and in many cases catches fire. It is composed of

Nitric acid	54—one atom.
Peroxide of copper	80—one atom.
	134

IX. *Subpernitrate of Copper.*—When a solution of potash is poured into a solution of pernitrate of copper, but not

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in sufficient quantity to decompose the dissolved salt completely, part of its acid is abstracted, and a supernitrate appears in the form of a precipitate, which is at first blue, but becomes green by agitation.

Percarbonate of copper.

X. *Percarbonate of Copper.*—This salt may be formed by precipitating a solution of pernitrate of copper, by a solution of carbonate of potash or of soda. It has a fine apple-green colour. It occurs native under the various names of malachite, blue copper ore, and anhydrous carbonate, according as it is modified by the presence or absence of water.

XI. *Perarseniate of Copper.*—Several varieties of this salt have been found in the copper mines of Cornwall in England.

Perarsenite of copper, or Scheele's green.

XII. *Perarsenite of Copper.*—*Scheele's Green.*—This salt may be obtained by the following process: Form two solutions; one by dissolving two parts of bipersulphate of copper (blue vitriol) in forty-four parts of water; and the other by dissolving, in the same quantity of water with the assistance of heat, two parts of common carbonate of potash (potash of commerce) and one part of arsenious acid (white oxide of arsenic). The latter solution will contain an arsenite of potash. Add gradually the solution of the bipersulphate, while hot, to the solution of the arsenite, stirring the whole frequently. The mixture upon standing, gradually deposites a fine green powder, which, after being well washed and dried, constitutes the perarsenite of copper.

XIII. *Perhydrofluate of Copper.*—Hydrofluoric acid does not act upon copper. This salt, however, may be formed by dissolving peroxide of copper in an excess of hydrofluoric acid. The solution, upon evaporation, deposites the salt in the form of small blue crystals.

XIV. PERACETATE OF COPPER.

Peracetate of copper, how obtained.

1. Acetic acid acts upon copper very slowly in open vessels, and exerts no action upon it in close ones. This salt, however, may be readily formed by dissolving peroxide of copper in acetic acid.

Verdigris; an impure peracetate. Preparation of verdigris.

2. Verdigris of commerce appears to be a mixture of peracetate and subperacetate of copper. But its composition is not invariable; and it very frequently contains a pretty large proportion of percarbonate of copper. Verdigris is commonly prepared by exposing plates of copper to the fumes of vinegar. In France, it is usually made by stratifying, in earthen pots, plates of copper with vine-stalks; the latter having previously undergone the acetous fermentation by being immersed in wine for a sufficient time. After the metallic plates have remained in this situation for from

ten to twenty days, they are taken out of the earthen pots, and placed on their edges in cellars, with their surfaces in contact; and during the course of seven or eight days, they are alternately dipped in water, and allowed to dry, for six or eight times during each day. They are then found to have swelled, and to be every where covered with a coat of verdigris. The verdigris may be easily scraped off with a knife, and is now in the state of a paste. It is afterwards beaten well with wooden mallets, and then packed in bags of white leather, in which it is dried by exposure to the air and sun. Verdigris, when good, is of a bluish-green colour, difficult to break, and free from black or white spots; it should not be deliquescent nor have a salt taste.

Its properties.

3. Peracetate of copper, when pure, is in the form of crystals of a bluish-green colour. Its taste is disagreeably metallic. It is but sparingly soluble in water. In the air, it suffers efflorescence. It is frequently used in dyeing. The impure peracetate (verdigris) is very much employed in the formation of green paints.

Properties of the pure peracetate.

4. Verdigris is very seldom used internally as a medicine; and when so employed, it acts as an emetic. Its external use is much more common. Dissolved in vinegar and afterwards mixed with honey, it forms the oxymel of verdigris, which is sometimes used to cleanse ulcers, more especially such as are venereal and are situated in the mouth and throat. But its use for the latter purpose is not convenient; as part of the preparation is liable to pass into the stomach, and thereby produce unpleasant consequences. When mixed with some mild ointment, it forms a gently escharotic application, which is well suited to particular states of external ulcers.

Uses in medicine.

Of the remaining salts of oxidized copper, there have been more or less examined by chemists, the potasso-sulphate, sulphite, potasso-sulphite, selenate, tellurate, nitrate, borate, phosphate, chromate, molybdate, tungstate, antimoniate, antimonite, sulphocyanate, purpurate, formate, oxalate, ammonio-oxalate, potasso-oxalate, soda-oxalate, sorbate, succinate, tartrate, potasso-tartrate, benzoate, saclactate, citrate, mellate, lactate, suberate and zumate; but these salts are of too little importance to be noticed. The rest of the salts of oxidized copper, amounting to 29, are unknown.

Salts of oxidized copper, omitted.

The salts of oxidized copper may be distinguished by the following properties or marks.

Their general properties.

1. They are almost all soluble in water, and their solutions are either blue or green.

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2. Their solutions are changed to a deep-blue colour by the addition of ammonia.

3. Ferrocyanate (triple prussiate) of potash occasions a red precipitate when poured into their solutions.

4. Hydrosulphate (hydrosulphuret) of potash occasions a black precipitate.

5. A plate of polished iron, by being plunged into their solutions, becomes covered with a coat of metallic copper.

SECTION XXV.

SALTS OF OXIDIZED BISMUTH.

Salts of oxidized bismuth; what compounds.

SALTS OF OXIDIZED BISMUTH are combinations of the oxide of bismuth with the different acids. Only four of these salts will be described.

Hydrochlorate of bismuth.

I. *Hydrochlorate of Bismuth.*—Usual chemical name, *Muriate of Bismuth.*—Hydrochloric acid, while cold, has scarcely any action upon bismuth; but when mixed with nitric acid, it is capable of dissolving the metal. The solution formed, upon evaporation, yields this salt in small crystals.

II. *Sulphate of Bismuth.*—Sulphuric acid acts upon bismuth by the assistance of heat, and converts the metal into a white powder. The sulphate formed, when treated with water, is divided into a supersulphate and a subsulphate of bismuth.

Oxidized bismuth forms two salts with nitric acid.

Nitric acid combines in two proportions with the oxide of bismuth, and forms nitrate and subnitrate of bismuth.

1. Nitrate.

III. *Nitrate of Bismuth.*—Nitric acid, when concentrated, acts with great violence upon bismuth, and converts it into a white powder. When diluted, it converts the metal into the same white powder, which becomes dissolved as soon as formed. This salt is deposited, from the solution, in the form of white crystals, which, upon exposure to air, attract a little moisture, and become covered with a white crust of hydrated oxide. On burning coals, they detonate feebly, and a yellow powder remains behind, not easily reduced to the metallic state.

IV. SUBNITRATE OF BISMUTH.

(Formerly called, *Magistery of Bismuth.*)

2. Subnitrate.

1. When the nitrate of bismuth in crystals, or the nitric solution of bismuth is treated with water, this liquid abstracts a portion of acid from the neutral salt, and a subnitrate of bismuth precipitates in the form of a white pow-

der. When the nitric solution is treated with chloride of sodium (common salt), or bitartrate of potash (cream of tartar), a subnitrate also appears to be formed. When thus prepared, it constitutes the paint, called pearl or flake white, which is sometimes used to give the skin a beautiful white colour.

Used in medicine.

2. Of late years, the subnitrate of bismuth has been introduced into practice, and, from the experience already had of it, appears to be well entitled to the attention of physicians. Its medical properties are those of a tonic and antispasmodic. In several deranged states of the stomach, as shown in violent pain or spasms in this organ, and in some cases of dyspepsia, it has been found, in the hands of several distinguished practitioners both in Europe and America, a very valuble remedy. Its medium dose is about two grains, given twice or thrice a-day. In severe cases, it may be given in doses of five grains.

Salts of oxidized bismuth, omitted.

Of the remaining salts of oxidized bismuth, there have been noticed by chemists, the sulphite, carbonate, borate, phosphate, arseniate, molybdate, sulphocyanate, oxalate, succinate, acetate, tartrate, and benzoate; but these salts are not of sufficient importance to be described. The rest of the salts of oxidized bismuth, amounting to 48, are unknown.

Their general properties.

The salts of oxidized bismuth may be recognised by the following properties or marks.

1. Their solutions in acids are usually colourless; but when water is added to them, a white precipitate makes its appearance.

2. Ferrocyanate (triple prussiate) of potash occasions in their solutions, a white precipitate, sometimes with a shade of yellow.

3. Hydrosulphate (hydrosulphuret) of potash occasions a dark-brown precipitate.

SECTION XXVI.

SALTS OF OXIDIZED MERCURY.

Salts of oxidized mercury; what compounds.

Salts of Oxidized Mercury are combinations of the oxides of mercury with the different acids. The following are the most important of these salts.

Oxidized mercury

Chloric acid forms a distinct salt with each of the oxides of mercury.

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forms two salts with chloric acid.

I. *Chlorate of Mercury.*—When chloric acid is poured upon protoxide of mercury, the latter becomes dissolved; and, as the solution proceeds, this salt precipitates in the form of yellowish grains. It is but sparingly soluble in water, and has a metallic taste. When heated, it detonates and gives out oxygen, being converted into perchloride of mercury (corrosive sublimate).

II. *Perchlorate of Mercury.*—Former chemical name, *Hyperoxymuriate of Mercury.*—This salt may be formed by dissolving peroxide of mercury in chloric acid. It always contains an excess of acid. It is pretty soluble in water, and has a strong taste, resembling that of perchloride of mercury (corrosive sublimate). When heated in a glass tube, it yields a considerable quantity of oxygen; and a yellow matter remains behind, which appears to be a mixture of peroxide of mercury, and the two chlorides of this metal (calomel and corrosive sublimate).

Hydrochlorate of mercury does not exist.

III. *Hydrochlorate of Mercury.*—Hydrochloric (muriatic) acid does not appear capable of combining with the oxides of mercury. When the attempt is made to produce this union, a double decomposition takes place; the hydrogen of the acid combines with the oxygen of the oxide, and forms water; while the chlorine of the former unites with the metallic mercury, and forms a chloride. The compounds, formerly considered to be muriates (hydrochlorates), under the names of calomel and corrosive sublimate, are now found to be chlorides of mercury. They have been already described under the head of mercury.

Oxidized mercury forms four salts with sulphuric acid.

Sulphuric acid combines in two proportions with protoxide of mercury, and forms sulphate and supersulphate of mercury; and in two proportions also with the peroxide, forming persulphate and superpersulphate of mercury. The salt of each oxide, with excess of acid, will be described before the neutral salt.

1. Supersulphate of mercury.

IV. *Supersulphate of Mercury.*—When sulphuric acid is boiled upon mercury, and the process stopped before the whole of the acid is driven off by evaporation, this salt is obtained in the form of a white mass, capable of reddening vegetable blues, possessing an acrid taste, and of different degrees of solubility, according to the proportional excess of acid which it may contain.

2. Sulphate.

V. *Sulphate of Mercury.*—This salt may be obtained by repeatedly washing the salt, last described, in small portions of water. The excess of acid, which it contains, is thereby separated, and it becomes reduced to the neutral state. It may be formed also by boiling sulphuric acid, diluted with its own weight of water, upon mercury. A

solution is formed, which, by proper evaporation, may be made to yield the salt in white crystals. It is not altered by exposure to air, but becomes decomposed by heat. It is soluble, without decomposition, in 500 parts of cold water, and in about 287 parts of boiling water. *Chap. IV.*

VI. *Superpersulphate of Mercury.*—If the process by which the supersulphate is formed be not discontinued while there yet remains an excess of acid, but the heat be kept up; part of the acid in excess is gradually decomposed, (sulphurous acid being disengaged), the protoxide of mercury combines with an additional atom of oxygen, and there results a salt, containing the peroxide with excess of acid. This salt appears to vary in the proportional excess of acid, which it may contain. When obtained at once in the form of a dry mass, it has a fine white colour, and is somewhat deliquescent. It contains considerably more than one atom of acid, united to an atom of base. 3. Superpersulphate.

VII. PERSULPHATE OF MERCURY.

(*Yellow Subsulphate of Mercury*, of the Edinburgh college —Formerly called *Turpeth Mineral.*)

1. When the salt last described is treated with water, the excess of acid which it contains is washed off, and a neutral persulphate remains behind. 4. Persulphate, or turpeth mineral.

2. This salt is directed by the Edinburgh college to be prepared by boiling, to dryness, three parts of sulphuric acid upon two parts of mercury; and throwing the white mass formed, previously pulverized, into boiling water. A powder immediately appears, which consists of the salt in question. Preparation for medical use.

3. It is generally supposed, that the treatment of the superpersulphate of mercury with water, separates this salt into a supersalt remaining in solution, and a subsalt, which precipitates; and consequently that the turpeth mineral is a salt with excess of base. But it has been correctly ascertained, that the salt, from which the turpeth mineral is precipitated, is already a supersalt; and that the effect of the treatment with water is merely to wash off the excess of acid, which it contains; whereby it becomes converted to the state of a neutral salt, which, being insoluble, appears in the form of a precipitate.

4. Persulphate of mercury, or turpeth mineral, has a bright yellow colour, and a somewhat acrid taste. It is soluble in 2000 parts of cold water, and in 600 parts of boiling water. Its specific gravity is 6·44. It is composed of Its properties.

Sulphuric acid	40—one atom.
Peroxide of mercury	216—one atom.
	256

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Forms an active medicine.

5. This salt constitutes a very active article of the materia medica, and is too much neglected by practitioners in the United States. Its most prominent virtue is its strong emetic property; which, considered in connection with its mercurial nature, would naturally lead, a priori, to the belief, that it is a preparation of great activity. When exhibited with a view to its emetic effect, it occasionally produces a salivation, unless this event is guarded against by the use of purgatives. It is said to be useful in swellings of the testicle from a venereal cause, and may be presumed, in such cases, to act both by its emetic and antisyphilitic powers. It has been employed also, with success, in inveterate diseases of the skin, and in obstinate glandular obstructions. When mixed with the powder of liquorice root, snuff, or some similar substance, it forms a very convenient errhine. In small doses of one or two grains, it acts as an alterative. Its dose, when exhibited with a view to its emetic property, is from two to eight grains.

Oxidized mercury enters into three nitrates.

Nitric acid is capable of combining with protoxide of mercury, with protoxide of mercury and ammonia, or with peroxide of mercury; and, in each combination, forms a distinct salt.

1. Nitrate of mercury.

VIII. *Nitrate of Mercury.*—Nitric acid, without the assistance of heat, is capable of dissolving very nearly its own weight of mercury; an effervescence takes place, owing to the emission of deutoxide of azote (nitrous gas), and the metal becomes protoxidized. The solution obtained is colourless, very heavy, and exceedingly caustic. It tinges the skin and almost all animal substances, of an indelible black colour. When treated with water, it does not separate into a supersalt and a subsalt. By spontaneous evaporation, it yields transparent crystals of the nitrate. When this salt is placed upon burning coals, it detonates feebly, emitting a lively white flame. When mixed with a little phosphorus, and struck with a hot hammer, a violent detonation takes place, and the mercury is revived.

IX. SUBNITRATE OF MERCURY-AND-AMMONIA.

(*Ash-coloured Oxide of Mercury* of the Edinburgh college.)

2. Ammonio-subnitrate.

1. This salt is ordered to be prepared by the Edinburgh college by the following process: Dissolve four parts of mercury in five parts of diluted nitrous acid; then gradually add fifteen parts of water. To the mixture, thus formed, add water of carbonate of ammonia as long as any precipitate appears. The precipitate, after being separated, washed and dried, constitutes the triple salt in question.

2. This salt is misnamed an oxide by the Edinburgh

college. The solution of mercury, in the nitrous acid of the colleges, forms, in fact, a solution of nitrate of mercury; for their nitrous acid is nitric acid holding deutoxide of azote (nitrous gas) in solution. The addition of the water of carbonate of ammonia throws down a subnitrate, combined with a portion of ammonia. Chap. IV.

3. Subnitrate of mercury-and-ammonia, prepared by the process just given, is a grey powder. It does not appear perfectly homogeneous. Acetic acid is capable of dissolving a portion of it, consisting perhaps of protoxide of mercury. The white powder, which remains behind, may be considered as the pure subnitrate. Properties.

4. This preparation is used, as a substitute for the protoxide of mercury prepared by trituration, to form a mercurial ointment; and although much more easily prepared than the oxide, it does not appear to be often employed. Uses in medicine.

X. PERNITRATE OF MERCURY.

1. When nitric acid is made to act upon mercury by the assistance of heat, a large quantity of deutoxide of azote (nitrous gas) is emitted, and the metal becomes peroxidized and converted into a yellow crystalline mass, constituting this nitrate. This salt is acrid and corrosive. When in solution and treated with cold water, it is divided into a supersalt which remains in solution, and a subsalt which precipitates in the form of a white powder. If the water with which the salt is treated be hot, the same division of it takes place; but the precipitated portion, instead of being white, is greenish-yellow. 3. Pernitrate.

2. Pernitrate of mercury, prepared in a certain way with hog's lard, forms the valuable ointment, called yellow, or citron-coloured ointment. The following is the method pursued by the colleges. Forms yellow ointment with hog's lard.

[1.] Dissolve one part of mercury in two parts of nitrous acid of the shops by digestion in a sand heat. While the solution, thus formed, is quite hot, add twelve parts of hog's lard, previously melted by itself, and just beginning to grow stiff. The lard must then be mixed intimately with the nitric solution, so as to form an ointment. What is called the milder yellow ointment is prepared in the same manner, there being three times the quantity of hog's lard employed.

[2.] The yellow ointment is an active preparation of mercury, well suited as an application to herpes, tinea capitis, and similar obstinate cutaneous affections. It is also particularly efficacious in venereal blotches, and ulcerations. Its chief inconvenience, as an ointment, is its tendency to become hard and pulverulent; which is owing to the excess of acid used in its preparation. This objection may be ob- Medical uses of yellow ointment.

viated by preparing the ointment, by mixing with hog's lard the subpernitrate of mercury, which is precipitated from the solution of the pernitrate by the addition of hot water. When thus formed, it continues perfectly soft, even for six months.

Carbonate of mercury.

XI. *Carbonate of Mercury.*—Carbonic acid does not act upon mercury; but when a carbonate of potash or of soda is dropped into a solution of nitrate of mercury, this salt appears in the form of a white precipitate.

XII PERPHOSPHATE OF MERCURY.

Perphosphate.

1. This salt may be formed most conveniently by mixing together solutions of phosphate of soda, and pernitrate of mercury. A double decomposition takes place, and perphosphate of mercury becomes precipitated.

How prepared for medical use.

2. It is directed to be prepared by the dispensatories in the following manner. Calcined bones (phosphate of lime) are decomposed by means of diluted sulphuric acid; and, after all the sulphate of lime (gypsum) formed is separated, the remaining superphosphate is saturated with pure potash. The liquid thus obtained, by evaporation, yields crystals of phosphate of potash. This salt is then dissolved in water, and decomposed by a solution of pernitrate of mercury. A precipitate immediately appears, which must be completely washed with warm water, and slowly dried; it is now pure perphosphate of mercury. What remains in solution, after the precipitate is separated, is nitrate of potash (nitre).

Properties.

3. Perphosphate of mercury is in the form of a white powder. Its specific gravity is 4·98. When rubbed in the dark, it phosphoresces. By distillation, it may be made to yield phosphorus.

Medical uses.

4. This salt has of late years been introduced into the practice of medicine. It has the usual properties of the mercurial preparations for internal use, but is far more active. It must, therefore, be exhibited with great caution, and in small doses. Even in doses not exceeding half a grain, it has produced violent vomiting and ptyalism. It is said to be preferable to all other preparations of mercury, in certain cases of the venereal disease, occurring in patients of torpid and insensible fibres. It is also said to have been found useful in exostosis, in obstructions of the lymphatic system, and in chronic complaints of the skin.

XIII. *Hydrofluate of Mercury.*—Hydrofluoric (fluoric) acid does not act upon mercury; but, by the assistance of heat, it is capable of dissolving its peroxide. The solution, by evaporation, deposites this salt in small yellow crystals. It always contains an excess of acid. By repeated affusions,

nearly all the acid may be washed away, leaving scarcely any thing behind but the peroxide. Chap. IV.

XIV. *Hydrocyanate of Mercury.*—This salt does not exist. When peroxide of mercury is heated in hydrocyanic acid vapour, a violent action takes place; much heat is evolved, and the compound is destroyed. When the same acid vapour is brought in contact with the peroxide, it becomes absorbed; and a compound is formed, which, by being heated, gives out water in a state of vapour, and is converted into the substance usually called prussiate of mercury. This substance, however, is in reality a cyanodide of mercury; since the water which appears is evidently the result of a mutual decomposition between the acid vapour and the peroxide. Now a similar decomposition is supposed to occur, whenever the attempt is made to form a hydrocyanate. Hence, therefore, the compounds, usually called prussiates, are in fact cyanodides. Hydrocyanate of mercury does not exist.

Acetic acid forms a distinct salt with each of the oxides of mercury. Oxidized mercury forms two salts with acetic acid.

XV. ACETATE OF MERCURY.

1. This salt may be prepared by mixing together the solutions of nitrate of mercury and acetate of potash, and setting the mixture aside to crystallize. In this case, a double decomposition takes place, which results in the formation of acetate of mercury and nitrate of potash. The former being much less soluble than the latter, enables the operator to separate it by crystallization. 1. Acetate of mercury.

2. Acetate of mercury is in the form of crystals, possessing a silver-white colour, and an acrid taste. It is but sparingly soluble in cold water, but dissolves readily in boiling water.

3. This acetate is sometimes employed in medicine, and has a place in the dispensatories. It is highly probable, that it claims no superiority over the preparations of mercury in common use. Used sometimes in medicine.

XVI. *Peracetate of Mercury.*—When peroxide of mercury is treated with acetic acid, it is dissolved; and the solution, when evaporated to dryness, forms a yellow deliquescent mass, which, when treated with water, divides into a supersalt remaining in solution, and a subsalt, which precipitates. 2. Peracetate.

Of the remaining salts of oxidized mercury, there have been more or less examined by chemists, the hydrosulphate, selenate, borate, arseniate, chromate, molybdate, tungstate, sulphocyanate, purpurate, oxalate, succinate, tartrate, po- Salts of oxidized mercury, omitted.

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tasso-tartrate, benzoate, saclactate, citrate, mellate, malate, lactate and zumate; but these salts are of too little importance to be noticed. The rest of the salts of oxidized mercury, amounting in number to 37, are unknown.

Their general properties.

The salts of oxidized mercury may be distinguished by the following properties or marks.

1. When strongly heated, they are generally volatilized.

2. Ferrocyanate of potash, dropped into their solutions, occasions a whitish precipitate, which becomes yellow upon exposure to the air.

3. Hydrosulphate (hydrosulphuret) of potash occasions a black precipitate.

4. When a plate of copper is placed in their solutions, the mercury is revived.

SECTION XXVII.

SALTS OF OXIDIZED SILVER.

Salts of oxidized silver; what compounds.

SALTS OF OXIDIZED SILVER are combinations of the oxide of silver with the different acids. The following are the most important of these compounds.

Chlorate of silver.

I. *Chlorate of Silver.*—Former chemical name, *Hyper-oxymuriate of Silver.*—This salt may be formed by dissolving oxide of silver in chloric acid. It is in the form of opaque crystals, which are soluble in water.

Hydrochlorate of silver does not exist.

II. *Hydrochlorate of Silver* does not exist. When the attempt is made to form this salt, water and chloride of silver (horn silver) become formed. This chloride was formerly called muriate of silver, from a wrong notion of its chemical composition.

III. *Iodate of Silver.*—When the solutions of nitrate of silver and iodate of potash are mixed together, a double decomposition takes place, and this salt falls in the form of a precipitate.

IV. *Sulphate of Silver.*—Sulphuric acid, while cold, does not act upon silver; but in a boiling temperature, it attacks this metal when reduced to the state of powder, the action being attended by the extrication of sulphurous acid gas, and converts it into a white mass, soluble in diluted sulphuric acid. This solution is colourless, and yields, upon evaporation, the salt in question in the form of brilliant white crystals. This salt is but sparingly soluble in water. It dissolves in nitric acid without decomposition. When heated,

it first melts, and afterwards is decomposed into silver, sulphurous acid and oxygen gas.

V. NITRATE OF SILVER.

(Common name, *Lunar Caustic.*)

Nitrate of silver, or lunar caustic.

1. Nitric acid acts readily upon silver, and dissolves about half its weight of this metal. The solution is attended by effervescence, owing to the disengagement of deutoxide of azote (nitrous gas). The nitric acid ought to be perfectly pure. If it contain hydrochloric (muriatic) acid, as the nitric acid of commerce always does, then a chloride of silver (horn silver) appears in the form of a white insoluble powder. It is by means of a solution of nitrate of silver, that manufacturers of nitric acid are enabled to separate any hydrochloric acid, with which their acid may be mixed. The nitric solution of silver is colourless, and exceedingly heavy and caustic. When evaporated until a pellicle begins to form on its surface, nitrate of silver is deposited in the form of brilliant crystals.

Its preparation for medical use.

2. The colleges direct this salt to be formed by dissolving pure silver in diluted nitrous acid of commerce, and evaporating the solution to dryness. The dry mass is next exposed, in a crucible, to a heat gradually increased, until it melts and flows like oil. It is then poured into cylindrical iron moulds, which are previously anointed with tallow, and heated.

Its properties.

3. Nitrate of silver is soluble in its own weight of cold water. It is not deliquescent in the air; but when exposed to a strong light, the silver is in part deoxidized. When heated, it melts, and when cool, it forms a grey coloured mass, crystallized internally in needles. It is only after fusion, that it is employed in medicine and surgery. When exposed to a red heat, or placed upon burning coals, it detonates, and the silver is revived. It has the property of detonating also, when mixed with phosphorus and struck with a hammer. Most of the metals, particularly mercury and copper, are capable of precipitating the silver from its solution in the metallic state. It is composed of

Nitric acid	54—one atom.
Oxide of silver	118—one atom.
	172

Uses in surgery;

4. Nitrate of silver is a very important salt in the hands of the surgeon. Its property of decomposing animal substances renders it useful in removing fungous excrescences and callous edges of ulcers, and for destroying strictures of the urethra. It is the most manageable caustic employed by surgeons; and, for the purposes just enumerated and

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many others, no other caustic can be used with equal advantage. In the form of a weak solution, it is a good stimulating application to indolent ulcers.

and in medicine.

It has been employed internally for the cure of epilepsy, and some other diseases. It must be admitted that it is an active substance; but how far it may be suited to the treatment of epilepsy, requires to be more satisfactorily ascertained. Its dose is one-fourth of a grain, repeated several times a day, and gradually increased.

Arsenite of silver.

VI. *Arsenite of Silver.*—When a solution of nitrate of silver is dropped into a solution containing arsenious acid, this salt falls in the form of a yellow precipitate, which afterwards becomes of a brown colour. The property, which the oxide of silver possesses, of combining with arsenious acid, whenever it meets with the latter, has suggested the employment of nitrate of silver for the detection of this deleterious substance.

VII. *Hydrofluate of Silver.*—Usual chemical name, *Fluate of Silver.*—Hydrofluoric (fluoric) acid has no action on metallic silver; and hence silver may be conveniently used in vessels for containing this acid; but it readily dissolves the oxide of silver. The hydrofluate, thus formed, has a strong metallic taste, and is very soluble in water. It does not crystallize.

Salts of oxidized silver, omitted.

Of the remaining salts of oxidized silver, there have been more or less described by chemists, the sulphite, selenate, nitrate, carbonate, borate, phosphate, arseniate, chromate, molybdate, sulphocyanate, purpurate, oxalate, succinate, acetate, tartrate, potasso-tartrate, benzoate, saclactate, citrate, mellate, malate, lactate and zumate; but these salts possess too little interest to be noticed. The rest of the salts of oxidized silver, amounting in number to 35, are unknown.

Their general properties.

The salts of oxidized silver may be distinguished by the following properties or marks.

1. When exposed to the action of the blow-pipe upon burning charcoal, they are decomposed, and a globule of silver is obtained.

2. Ferrocyanate of potash occasions, in their solutions, a white precipitate.

3. Hydrosulphate (hydrosulphuret) of potash occasions a black precipitate.

4. Hydrochloric (muriatic) acid, or the chlorides of potassium or of sodium occasion a white heavy flaky precipitate, resembling curd. This precipitate is chloride of silver (horn silver).

5. A solution of sulphate of iron precipitates the silver in the metallic state from solutions of these salts. Chap. IV.

6. A plate of copper, placed in their solutions, precipitates the silver in the metallic state.

SECTION XXVIII.

SALTS OF OXIDIZED GOLD.

Salts of oxidized gold; what compounds.

Salts of Oxidized Gold are combinations of the peroxide of gold with the different acids. Unless there exists a simple hydrochlorate of gold, which is very doubtful, the protoxide of gold enters, as a constituent, into no salt. Only three of these salts are certainly known: they are the following.

I. PERHYDROCHLORATE OF GOLD.

(Usual chemical name, *Muriate of Gold.*)

Perhydrochlorate of gold.

1. When a mixture of one part of nitric acid and four parts of hydrochloric acid is poured upon gold, the metal is immediately attacked, the action being attended with effervescence, owing to the disengagement of deutoxide of azote (nitrous gas). The solution formed is of a deep yellow colour. It has the property of tinging the skin, as well as almost all animal and vegetable substances, of a deep purple colour. When evaporated, perhydrochlorate of gold is deposited in crystals, possessing a fine yellow colour.

Its properties.

2. This salt is exceedingly deliquescent. Its taste is acrid and somewhat bitter, but not in the least metallic. When heated, it gives out chlorine, and is converted into a straw-coloured mass, which is supposed to be the simple hydrochlorate. It is decomposed by the alkaline salifiable bases, peroxide of gold being precipitated in the form of a yellow powder; but ammonia, potash or soda, if added in sufficient quantity, re-dissolves this precipitate, and forms a triple salt. It is decomposed also by most of the metals, and the gold thrown down, either in the metallic state, or in the form of a purple powder. When iron, zinc, copper, bismuth, or mercury is plunged into its solution, the gold is precipitated in the metallic state. The gold is precipitated in the form of a purple powder by lead, tin or silver. It is precipitated also, from the solution of this hydrochlorate, by means of sulphate of iron, which becomes converted into a persulphate; but no effect is produced by the persulphate of iron ready formed. By a similar action, hydrochlo-

rate of tin throws down protoxide of gold, combined with peroxide of tin; the tin being peroxidized, and the gold reduced to the state of protoxide, by a transfer of oxygen from the latter to the former. This compound oxide is the purple precipitate of Cassius, and is used to give a red colour to porcelain and glass. On the other hand, the perhydrochlorate of tin has no effect on the solution of the perhydrochlorate of gold; as the oxide, which it contains, is already combined with a maximum of oxygen, and is, therefore, incapable of reducing the gold to the state of protoxide.

It is precipitated by hydrochlorate of tin, the precipitate being the purple powder of Cassius.

Proposed as an antisyphilitic remedy.

3. Different preparations of gold have been proposed by Dr. Chrestien as antisyphilitic remedies. The use of the peroxide with this view has already been noticed. Besides this oxide, Dr. Chrestien has proposed the perhydrochlorate just described combined with chloride of sodium (common salt), the purple powder of Cassius, and the ammoniated oxide. All of them were employed by friction on the tongue, cheeks and gums. The preparation of the perhydrochlorate is by far the most active of those which he employed, and was prescribed by him in doses of from $\frac{1}{15}$th to $\frac{1}{10}$th of a grain, mixed with starch or charcoal.

Persulphate of gold.

II. *Persulphate of Gold.*—When peroxide of gold is treated with warm sulphuric acid diluted with water, a solution of this salt is formed, having a yellow colour and a very styptic taste, and always containing an excess of acid.

Pernitrate.

III. *Pernitrate of Gold.*—When concentrated nitric acid is poured upon peroxide of gold, it is dissolved; and there is formed a solution of this salt, possessing a brown colour, and containing an excess of acid. When treated with water, the peroxide is precipitated.

The remaining salts of oxidized gold, amounting in number to 60, are unknown.

Salts of oxidized gold; how known.

The salts of oxidized gold may be distinguished by the following properties or marks.

1. Their solutions in water have a yellow colour.
2. Ferrocyanate of potash occasions a white or yellowish-white precipitate, when poured into their solutions.
3. A plate of tin or hydrochlorate of tin occasions the purple precipitate of Cassius.
4. Sulphate of iron throws down the gold in the metallic state.

SECTION XXIX.

SALTS OF OXIDIZED PLATINUM.

SALTS OF OXIDIZED PLATINUM are combinations of the oxides of platinum with the different acids. Two only of these salts will be described. Salts of oxidized platinum; what compounds.

I. *Perhydrochlorate of Platinum.*—Usual chemical name, *Muriate of Platinum.*—When sixteen parts of a mixture, composed of one part of the strongest nitric acid and three parts of hydrochloric acid, are boiled upon one part of platinum, the solution of the metal is gradually effected, being attended with a violent effervescence. The solution formed is at first of a yellow colour, which gradually deepens until it becomes of a deep red. It is exceedingly acrid and caustic, and tinges the skin of an indelible dark-brown colour. When sufficiently concentrated by evaporation, perhydrochlorate of platinum is deposited in the form of crystals of a reddish-brown colour. This salt has a disagreeable, astringent, metallic taste, When cautiously heated nearly to redness, it is converted into perchloride of platinum. If the heat be still farther increased, the chlorine is driven off and nothing remains but the pure platinum. Perhydrochlorate of platinum.

II. *Sulphate of Platinum.*—This salt may be obtained by boiling to dryness, in nitric acid, the black powder precipitated from a solution of platinum in hydrochloric acid assisted by nitric acid, by means of hydrosulphuric acid gas, passed through it in a stream. This black powder is a sulphuret of platinum, mixed with hydrosulphuric acid and sulphur. When it is boiled to dryness in nitric acid, the sulphur becomes acidified, and the platinum oxidized, whereby it is converted into a sulphate of platinum. This salt is in the form of a porous crust, of a dark-brown colour, approaching to black. It is brittle and easily reduced to powder. Its taste is acid, metallic and somewhat caustic. It has the property of slightly reddening vegetable blues. It is very deliquescent, and consequently very soluble in water. The sulphuric acid cannot be separated from it by the usual methods, owing to the tendency which it possesses of forming triple salts with most of the alkaline and earthy salifiable bases. When heated to redness, it is entirely decomposed; oxygen and sulphurous acid being disengaged, and a strong fuming sulphuric acid, obtained. The residuum consists of pure platinum. Sulphate of platinum. Forms triple salts.

The following are the triple salts which this sulphate is capable of forming; namely, the ammonio-sulphate, potasso-

sulphate, soda-sulphate, baryto-sulphate and alumino-sulphate. These compounds, however, are purposely omitted, as being of too little importance to be described. The rest of the salts of oxidized platinum are unknown.

General properties of the salts of oxidized platinum.

The salts of oxidized platinum may be distinguished by the following properties or marks.

1. Their solutions in water have a brown or a yellowish-brown colour.

2. Ferrocyanate of potash occasions no precipitate in their solutions.

3. Ammonia and potash occasion the precipitation of small orange-coloured crystals.

4. Hydrosulphuric acid gas occasions a black precipitate.

SECTION XXX.

SALTS OF OXIDIZED PALLADIUM.

Salts of oxidized palladium; what compounds.

SALTS OF OXIDIZED PALLADIUM are combinations of the oxide of palladium with the different acids. Only three of these compounds will be noticed.

Hydrochlorate of palladium.

I. *Hydrochlorate of Palladium.*—Usual chemical name, *Muriate of Palladium.*—Hydrochloric acid, even when assisted by heat, acts but slowly upon palladium; but by the assistance of nitric acid, it dissolves the metal with great violence, and forms a red solution containing this salt.

Besides this simple salt, hydrochloric acid and oxide of palladium form three triple salts, by combining with either ammonia, potash or soda. But these salts are not of sufficient importance to be noticed.

Sulphate.

II. *Sulphate of Palladium.*—Sulphuric acid, when boiled upon palladium, dissolves a small portion of the metal, and assumes a beautiful red colour. The properties of the sulphate, which is thus formed, have not been examined.

Nitrate.

III. *Nitrate of Palladium.*—Strong and colourless nitric acid acts but feebly upon palladium, no deutoxide of azote (nitrous gas) is extricated, and it gradually assumes a red colour. When, however, the acid contains deutoxide of azote, the action is much more rapid. The solution formed, by evaporation, yields a red mass consisting of this salt.

The remaining salts of oxidized palladium are unknown.

General properties of the salts

The salts of oxidized palladium may be distinguished by the following properties or marks.

1. They are almost all insoluble in water. Their solutions in acids have a fine red colour. *Chap. IV. of oxidized palladium.*

2. Ferrocyanate of potash occasions a dirty yellow-brown precipitate, when dropped into their solutions.

3. Hydrosulphate of potash occasions a blackish-brown precipitate.

4. Ammonia, potash or soda occasions an orange-coloured precipitate.

5. Mercury and sulphate of iron throw down the palladium in the metallic state.

SECTION XXXI.

SALTS OF OXIDIZED RHODIUM.

Salts of oxidized rhodium; what compounds.

Salts of Oxidized Rhodium are combinations of peroxide of rhodium with the different acids. The deutoxide is not known to be a salifiable base, and it is doubtful whether the protoxide enters into the composition of any salt. Only three of these salts will be described.

Perhydrochlorate of rhodium.

I. *Perhydrochlorate of Rhodium.*—Peroxide of rhodium dissolves in hydrochloric acid, and forms a rose-coloured solution, which does not crystallize. When hydrochlorate of ammonia (sal ammoniac) or nitrate of potash (nitre) is added to this solution, no precipitate appears; but a triple salt is formed with ammonia or potash, according to the substance added.

Persulphate.

II. *Persulphate of Rhodium.*—When hydrosulphate (hydrosulphuret) of ammonia is mixed with the compound of chloride of sodium and peroxide of rhodium, a sulphuret of rhodium precipitates. When fuming nitric acid is boiled to dryness upon this sulphuret, it becomes changed into a persulphate. This salt deliquesces in the air, and assumes a red colour. When dissolved in water and evaporated, it is converted into a syrupy, orange-coloured mass.

Pernitrate.

III. *Pernitrate of Rhodium.*—Peroxide of rhodium dissolves in nitric acid, and forms a red solution, which does not crystallize.

The rest of the salts of oxidized rhodium are unknown.

Salts of oxidized rhodium, how known.

The salts of oxidized rhodium may be distinguished by the following properties or marks.

1. Their solutions in water are red.

2. Neither ferrocyanate nor hydrosulphate of potash occasion any precipitate in their solutions.

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3. Ammonia, potash or soda throws down from their solutions a yellowish powder, soluble in excess of these alkaline bases.

SECTION XXXII.

SALTS OF OXIDIZED IRIDIUM.

Salts of oxidized iridium.

THESE salts have heretofore been but very imperfectly examined: the only one which has been formed is the hydrochlorate. They may be recognised by the following marks.

1. They are soluble in water. The solution is at first green, but afterwards, by concentration in the open air, becomes red.

2. Their solutions are rendered colourless, when ferrocyanate of potash, or infusion of nut-galls is dropped into them.

SECTION XXXIII.

SALTS OF OXIDIZED OSMIUM.

Salts of oxidized osmium do not, strictly speaking, exist.

IT has already been mentioned, that, strictly speaking, the oxide of osmium is not a salifiable base, and consequently that no such compound as a salt containing this oxide is known to exist. But it is reasonable to suppose, that it is unknown as a salifiable base, not because it is incapable of forming salts, but in consequence of the imperfect manner in which its chemical relations have been investigated.

SECTION XXXIV.

SALTS OF OXIDIZED TITANIUM.

Salts of oxidized titanium; what compounds.

THESE salts are combinations of the protoxide or peroxide of titanium with different acids. The deutoxide is not known to enter into the composition of any salt. Only four of these compounds will be noticed.

I. *Perhydrochlorate of Titanium.*—Usual chemical name, *Muriate of Titanium.*—Hydrochloric acid has no action on deutoxide of titanium; but it dissolves readily the percarbonate.

II. *Sulphate of Titanium.*—Boiling sulphuric acid has no action upon deutoxide of titanium; but it oxidizes and dissolves a portion of metallic titanium. The solution, when evaporated, is converted into a white, opaque, gelatinous mass. Chap. IV.

III. *Pernitrate of Titanium.*—Nitric acid exerts no action upon deutoxide of titanium, and scarcely any on the metal itself; but it dissolves, by the assistance of heat, the percarbonate of titanium. The solution, when evaporated, yields transparent crystals of this nitrate.

IV. *Percarbonate of Titanium.*—This salt may be formed by melting together one part of deutoxide of titanium, and six parts of carbonate of potash, and washing the mass formed completely with water. A white powder, with a slight red tinge, is left behind undissolved, which consists of the percarbonate.

The rest of the salts of oxidized titanium are unknown.

Their distinguishing properties.

The salts of oxidized titanium may be known by the following characters.

1. They are generally colourless, and, in some degree, soluble in water.

2. Carbonate of potash or of soda occasions a white flaky precipitate in their solutions.

3. Ferrocyanate of potash occasions a grass-green precipitate, mixed with brown.

4. Hydrosulphate of potash occasions a dirty grass-green precipitate.

5. Infusion of nut-galls occasions a very bulky reddish-brown precipitate.

SECTION XXXV.

SALTS OF OXIDIZED ANTIMONY.

Salts of oxidized antimony; what compounds.

The reader has already been informed, that of the three compounds formed by antimony with oxygen, that one only, which contains the least oxygen, is a salifiable base. The other two are acids, and, according to the quantity of oxygen which they contain, are distinguished by the names of *antimonious* and *antimonic* acids. It is this circumstance of the different agency of these compounds, in the formation of salts, which has led to the classification of antimony as an intermediate combustible. The salts to be described here are accordingly compounds of the oxide of antimony with the different acids.

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Oxide of antimony combines with hydrosulphuric acid, forming hydrosulphate of antimony, or kermes mineral.

Oxide of antimony is not known to combine with sulphuric acid; but with hydrosulphuric acid (sulphuretted hydrogen), it forms hydrosulphate of antimony.

I. HYDROSULPHATE OF ANTIMONY.

(Usual chemical name, *Hydrosulphuret of Antimony.*—*Brown Antimoniated Sulphur*, of the Dublin college.—Common name, *Kermes Mineral.*)

1. When hydrosulphate of ammonia or of potash is dropped into an acid solution of antimony, this salt precipitates in the form of a beautiful orange-coloured powder.

Its preparation for medical use.

2. It is directed to be prepared by the Dublin college by the following process: Melt together equal parts of prepared sulphuret of antimony and carbonate of potash in a crucible; and when the mass is cool, reduce it to powder, and then boil it in a glass vessel with forty times its weight of water for an hour. The vessel is then taken off the fire, and as soon as the liquor has become clear, it is cautiously decanted and set aside to cool. During the cooling, the hydrosulphate is deposited in the form of a powder.

3. The manner in which the hydrosulphate is formed, in the foregoing process, is thus explained. Upon fusing together carbonate of potash and sulphuret of antimony, carbonic acid is disengaged, and the mass obtained is a mixture of the sulphurets of antimony and of potash. Water, by being boiled upon the mixed sulphurets, becomes decomposed; its oxygen oxidizes the antimony, while its hydrogen converts the sulphur into hydrosulphuric acid. Part of the acid, thus formed, combines with the oxide of antimony, while the remainder unites with the potash; so that the mixed sulphurets become a mixture of hydrosulphate of antimony and hydrosulphate of potash. Now the former of these salts is soluble, at the boiling temperature, in the latter, but not at the ordinary temperature of the air: hence, therefore, it precipitates as the liquid cools.

4. The method of preparing this salt was first discovered by Glauber, and afterwards by Lemery, the elder. It acquired great celebrity, as a medicine, about the beginning of the last century. Its preparation was kept secret before 1720, in which year the French government purchased the process and made it public.

Its composition.

5. Kermes mineral, when obtained from the sulphuret of antimony and potash, was found by Thenard to consist of

Hydrosulphuric acid	20·30
Oxide of antimony	72·76
Sulphur	4·15
Water and loss	2·79
	100·00

This analysis does not agree well with any atomical supposition for the composition of this salt. It evidently appears that the compound cannot be much modified, in its medical properties at least, by the presence of 4 per cent. of sulphur. Kermes mineral may therefore be considered, without much want of precision, a hydrosulphate of antimony.

Hydrosulphite of antimony, or golden sulphur.

6. When the liquor, from which the kermes mineral has precipitated, is treated with diluted sulphuric acid, a precipitate is formed, which differs in composition, from the one last described, in containing a larger proportion of sulphur. According to the plan of nomenclature adopted in this work, it may be called a *hydrosulphite of antimony*. Its usual chemical name is *hydroguretted sulphuret of antimony*, formerly called, *golden sulphur*. It is officinal with the British colleges.

Medical properties of kermes mineral; and of golden sulphur.

7. Kermes mineral is an active preparation of antimony, and certainly not sufficiently attended to by medical practitioners in the United States. It has the usual properties of the antimonial remedies. Its dose is from a grain to a grain and a half. It is very apt to excite vomiting. The golden sulphur is very similar, in medical properties, to the kermes mineral; but on account of the additional quantity of sulphur which it contains, it may be given in larger doses.

Oxide of antimony, combined with phosphate of lime, forms phosphate of lime-and-antimony, or James's powder.

Oxide of antimony is not known to combine with phosphoric acid; but with phosphate of lime, it forms phosphate of lime-and-antimony.

II. PHOSPHATE OF LIME-AND-ANTIMONY.

(*Oxide of Antimony with Phosphate of Lime*, of the Edinburgh College. Common names, *Antimonial Powder—James's Powder*.)

1. This compound is directed to be prepared by the British colleges by the following process. Put a mixture of equal parts of sulphuret of antimony and shavings of hartshorn in a red-hot iron pot, and stir it constantly, until it is burnt into a mass of a grey colour. It is then removed from the fire, ground into a powder, and placed in a crucible, over which there is luted another, perforated at its bottom. The mass is now exposed to a white heat gradually raised, and kept at that temperature for two hours. It is then withdrawn from the fire, and, when cold, ground into a fine powder. It now constitutes the preparation in question.

2. To understand the foregoing process, it must be recollected, that shavings of hartshorn are phosphate of lime containing some animal matter. When they are exposed to a white heat, the animal matter is burnt off, and they become converted into pure phosphate of lime. During the

same exposure, the sulphuret of antimony, with which the shavings are mixed, becomes converted into oxide of antimony, and, thus altered, combines with the phosphate.

3. The formula, just given, was invented by Dr. Pearson of London. It furnishes a preparation, which agrees in constituents with the celebrated antimonial powder of Dr. James.

Its composition.

4. This triple salt is composed of

Phosphate of lime	43
Oxide of antimony	57

Its medical properties.

5. Phosphate of lime-and-antimony is a very valuble antimonial preparation. In doses of from three to eight grains, repeated every third or fourth hour, it is well suited to the treatment of febrile diseases, and acts as a diaphoretic and antiphlogistic remedy. In larger doses, its operation is both emetic and cathartic.

Oxide of antimony forms a triple salt with bitartrate of potash, called tartrate of potash-and-antimony, or tartar emetic.

Tartaric acid has no action upon metallic antimony, and is capable of dissolving small portions only of its oxide; but bitartrate of potash (tartar) combines with the oxide, and forms tartrate of potash-and-antimony.

III. TARTRATE OF POTASH-AND-ANTIMONY.

(*Tartrite of Antimony* of the Edinburgh college.—Also called, *Tartarized Antimony—Antimoniated Tartar.*—Common name, *Tartar Emetic.*)

1. The London and Edinburgh colleges direct the preparation of this triple salt by the following process: Boil a mixture of three parts of crocus of antimony (a sulphuretted oxide of antimony) and four parts of bitartrate of potash (tartar), in thirty-two parts of distilled water, in a glass vessel, for about a quarter of an hour. Filter the liquor through paper, and set it aside to crystallize.

2. In the above process, the oxide of antimony is dissolved in the extra atom of acid of the bitartrate of potash; so that there is formed a tartrate of antimony, while the bitartrate is reduced to a tartrate (soluble tartar). The tartrate of antimony, however, does not combine with all the tartrate of potash formed, but a proportion of it only. Hence it is that the liquid, from which tartar emetic is deposited, is a solution of tartrate of potash.

3. Besides the crocus of antimony, several other forms of oxide of antimony have been employed in the formation of this triple salt. These are the glass of antimony (a sulphuretted oxide) and subhydrochlorate of antimony (powder of Algaroth). When the glass is used, its sulphur is left undissolved, as is the case with the crocus; and when the subhydrochlorate is employed, the small portion of acid, which it contains, combines with the potash of the bitartrate

and remains in solution. The Dublin college employs the uncombined oxide of antimony, which is precipitated from chloride of antimony (butter of antimony) by means of carbonate of potash. This is perhaps the best method for preparing tartar emetic; but at the same time it is the most expensive. Chap. IV.

Properties of tartar emetic.

4. Tartrate of potash-and-antimony has a white colour and a crystalline appearance. When exposed to the air, it effloresces and loses its transparency. It is soluble in fifteen parts of water at the temperature of 60°, and in three parts of boiling water. When exposed to heat, its acid is destroyed, and there remains behind a mixture of potash and oxide of antimony. It is decomposed by the alkaline salifiable bases and their carbonates, by the hydrosulphates, and by several of the metals. It is decomposed also by vegetable juices, and by decoctions of vegetable substances, especially of such as are astringent and bitter. Hence care must be taken not to associate these substances with tartar emetic in compound prescriptions.

Its composition.

5. The composition of tartar emetic may be thus stated: 182 parts, or one atom of bitartrate of potash require for saturation 98 parts of oxide of antimony. As, however, the oxide combines only with the extra atom of acid in the bitartrate, there consequently results

165 parts of tartrate of antimony, composed of
 67 parts, or one atom of tartaric acid, and
 98 parts of oxide of antimony; and
115 parts, or one atom of tartrate of potash, composed of
 67 parts, or one atom of tartaric acid, and
 48 parts, or one atom of potash.

The 165 parts of tartrate of antimony, during the precipitation of the tartar emetic, combine with 72 parts only of the tartrate of potash formed, the remainder of the tartrate of potash, amounting to 43 parts, being held in solution.

The above numbers are calculated from an analysis performed by Thenard. It is easy to perceive that they do not accord with any supposition of atomic combination.

Tartar emetic is of indispensable utility in the practice of medicine.

6. Tartrate of potash-and-antimony is of indispensable utility in the practice of medicine. In doses of from three to five grains, it is a prompt and effectual emetic: and in doses of from one-eighth to one-fourth of a grain, repeated at short intervals, it is one of the most certain means of repressing febrile action, which can be employed. When dissolved in wine, it forms the valuable medicine, familiarly known by the name of antimonial wine. This preparation is officinal with the different colleges; but it is to be regretted, that

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it is not of uniform strength. The wine ordered by the Edinburgh college contains two grains of the triple salt to the ounce; while the wines of the London and Dublin colleges contain twice that quantity.

Salts of oxidized antimony, omitted.

Besides the salts of oxidized antimony just described, there have been formed and slightly noticed by chemists, the oxalate, acetate and benzoate. The rest of these salts are unknown.

Their general properties.

The salts of oxidized antimony may be recognised by the following properties or marks.

1. Their solutions in acids are usually of a brownish-yellow colour, and in most cases let fall a white precipitate upon the addition of water.

2. Hydrosulphate of potash occasions an orange-coloured precipitate in their solutions.

3. When a plate of iron or zinc is plunged into their solutions, a black precipitate immediately forms.

SECTION XXXVI.

SALTS OF OXIDIZED TELLURIUM.

Salts of oxidized tellurium; what compounds.

These salts are the compounds, into which oxide of tellurium enters as a constituent, not as an acid, but as a base. It was the double office of the oxide of tellurium in its different saline combinations, which caused the metal itself to be associated with antimony, under the title of intermediate combustibles. Tellurium, however, differs from antimony in this respect, that, being capable of forming but one oxide, the same oxide, under different circumstances, appears both as an acid and as a salifiable base; whereas it is different oxides of antimony, which assume the double office.

The hydrochlorate, sulphate and nitrate of tellurium have been formed by Berzelius; but they are too unimportant to be described. No other salts, into which the oxide of tellurium enters as a salifiable base, are known.

General properties of the salts, into which oxide of tellurium

The salts, into which the oxide of tellurium enters as a constituent, may be recognised by the following characters.

1. Potash or soda, when dropped into their solutions, occasions a white precipitate, which disappears when either of these alkaline bases is added in excess.

2. Ferrocyanate of potash occasions no precipitate; but hydrosulphate of potash throws down a brown or blackish precipitate. CHAP. V. enters as a constituent.

3. Iron, zinc, and antimony throw down the tellurium in the form of a black powder, which acquires the metallic lustre when rubbed.

CHAPTER V.

OF UNSALIFIABLE COMPOUNDS.

IT is proposed, in the present chapter, to treat of the more important unsalifiable compounds. They will be arranged under the six following heads:

1. Alcohol.	4. Fixed oils.
2. Ethers.	5. Spermaceti.
3. Volatile oils.	6. Soaps.

These heads will furnish the titles of the six following sections.

SECTION I.

OF ALCOHOL.

(Common name, *Spirit of Wine.*)

1. BY the distillation of various fermented liquors, a peculiar liquid is obtained. The distilled product of wine is brandy; of the fermented juice of the sugar cane, rum; and of the fermented juice of the apple or of the fermented infusion of malt, whiskey or gin. All these different kinds of ardent spirits are essentially the same. They consist of pure spirit or alcohol, diluted with water, and containing a little oil or resin, to which they owe their flavour and colour.

Product of the distillation of fermented liquors.

Ardent spirit is diluted alcohol.

When these ardent spirits are distilled, there is obtained a light transparent liquid, known in commerce by the name of rectified spirits. This liquid, however, is not pure alcohol; it still contains a considerable portion of water.

The method, formerly practised to separate the water from the rectified spirits, was to mix them with carbonate of potash (salt of tartar), previously made dry and warm.

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This salt is insoluble in pure alcohol; but combines with avidity with water. Hence it is, that, upon being mixed with the spirits, it separates the greater part o the water which they contain, and falls to the bottom of the vessel employed. The spirits have now become lighter and purer than before; but they still contain a considerable quantity of water.

Absolute alcohol, first obtained by Lowitz.

Alcohol, absolutely pure, was first obtained, in 1796, by Lowitz of Petersburgh. The process of this chemist is as follows: Mix together, in a retort, two parts of carbonate of potash, perfectly dry and still warm, and one part of alcohol, brought to the specific gravity of 0.821, by means of the common treatment with carbonate of potash. This mixture forms a solid mass, without any superabundance of alcohol. Allow it to remain for twenty-four hours, and then distil by a heat, so gentle as that about two seconds will elapse between the falling of the drops of the distilled liquor from the beak of the receiver. When the interval becomes greater, the process must be stopped. In this way, an alcohol is obtained of the specific gravity of 0·791: it may be considered as absolute or pure alcohol.

Richter obtained alcohol of the specific gravity of 0·792, by distilling an alcohol of the specific gravity of 0·821, off a little more than its weight of chloride of calcium (muriate of lime), pulverized and yet warm, and which had previously been exposed to a red heat.

Properties of absolute alcohol.

2. Absolute alcohol, obtained by the processes just given, is a transparent colourless liquid, possessing a pleasant smell, and strong, penetrating, agreeable taste. Its specific gravity, as has already been mentioned, is 0·791. When mixed with water, its specific gravity becomes higher in proportion to the quantity added, and the mixture is attended by a condensation. Hence the purest spirits are those which are specifically the lightest.

3. Alcohol does not congeal, when exposed to the greatest artificial cold which has hitherto been produced. It has been subjected to a cold of $-91°$ without losing its liquidity.

4. It is a very volatile liquid. When of the specific gravity of 0·820, its boiling point is at 176°. In a vacuum, it boils at the temperature of 56°. From this it is evident, that, were it not for the weight of the atmosphere, it would always exist in the form of an elastic vapour. This vapour possesses the mechanical properties of common air. Its specific gravity is 1·61.

5. When alcohol is exposed to a high temperature, it takes fire and burns with a blue flame, leaving no residuum. The products of its combustion are water and carbonic acid.

6. Alcohol is capable of dissolving a small portion of phosphorus. It dissolves a portion of sulphur also. When water is added to sulphuretted alcohol, the sulphur is precipitated.

7. Alcohol has the property of combining with ammonia; with which it forms the officinal preparation, called ammoniated alcohol, or spirit of ammonia. This compound is best prepared by mixing together one part of hydrochlorate of ammonia (sal ammoniac) and two parts of lime, and pouring upon the mixture, placed in a retort, four parts of alcohol. The whole is then distilled to dryness. The hydrochloric acid of the hydrochlorate combines with the lime in such a way as to form chloride of calcium and water; while the ammonia, combined with the alcohol, distils over.

It ... with ... monia, forming ammoniated alcohol.

Several active articles of the materia medica are dissolved in ammoniated alcohol. The compounds thus formed are called ammoniated or volatile tinctures.

Ammoniated alcohol, used as a solvent for several active medicines.

8. Alcohol is capable also of dissolving potash and soda, and forms with them, a reddish-coloured acrid solution. It is by means of alcohol, that these alkaline bases are generally obtained in a pure state. It is decomposed by the action of sulphuric and nitric acids; but all the other acids are soluble in it, except phosphoric acid and the metallic acids. It is capable of dissolving a considerable number of salts. Some of these compounds, however, are entirely insoluble in it. When it holds in solution certain substances, their presence is indicated by the peculiar colour of its flame. Thus boracic acid and the salts of oxidized copper tinge its flame green; nitrate of strontian, purple; chloride of calcium, red; nitrate of potash and perchloride of mercury, yellow.

9. It is composed of

Composition of alcohol.

Hydrogen	3—three atoms.
Carbon	12—two atoms.
Oxygen	8—one atom.
	23

The atomic statement, above given, of the ultimate constituents of alcohol coincides very nearly with an analysis, performed with great care by Theodore de Saussure, in 1813: it may, therefore, be considered a pretty near approximation to truth. The proximate constituents of this liquid are unknown; as there are no data, by which to indicate the manner in which its ultimate constituents are united.

10. The effects of alcohol in a diluted state upon the human body, under the various forms of ardent spirits, are too well known to require detail. They are certainly those

Effects of alcohol on the human

This ... and diffusive stimulus. In pharmacy, ... the diluted state, is very much em- ... virtues of certain medicinal substances. ...rmed, are called tinctures. It is to be ...hat so many medicines are exhibited, ...enstruum, more especially in chronic ...ual use not unfrequently renders the ...l, at first merely grateful to the sto- ...ably necessary, to create, artificially, ... of animal feeling, without which to live is to be miserable.

SECTION II.

OF ETHERS.

General properties of ethers.

Ethers are very fragrant and volatile liquids, formed by distilling alcohol with various acids. The reader has already been made acquainted with the liquid formed by the union of hydroguret of carbon (olefiant gas) and chlorine, under the name of chloric ether. Besides this compound, six distinct ethers have been described by chemists; namely *hydrochloric* (*muriatic*) *ether*, *hydriodic ether*, *sulphuric ether*, *nitric ether*, *formic ether*, and *acetic ether*. Three only of these ethers will be described; namely hydrochloric, sulphuric and nitric ethers.

I. OF HYDROCHLORIC ETHER.

(Usual chemical name, *Muriatic Ether*.)

Hydrochloric ether; how obtained.

1. This ether may be obtained by distilling a mixture of equal bulks of hydrochloric acid and alcohol, both obtained as strong as possible. The retort, from which the distillation is made, must have a tube luted to its beak, which should communicate with a glass jar, half full of water, and furnished with three mouths. From the middle mouth, a tube of safety should proceed; and from the third mouth, a tube, so connected with the pneumatic trough, as to enable the operator to collect the gaseous product. As soon as the heat is applied, the gaseous product passes to the vessels in the water trough; while any alcohol, acid or water, which may be driven over, is arrested in the jar with the three mouths. The gas thus obtained is hydrochloric ether.

Properties.

2. Hydrochloric etherial gas has the strong smell of ether, and a sweetish taste. Its specific gravity is 2·219. When exposed to a cold of 52°, it is condensed into a liquid, in which state it is colourless and has the same taste and

smell as when in the form of gas. At the temperature of 41°, its specific gravity is 0·874. It burns readily with a green flame; and, at the same time, a very considerable portion of hydrochloric acid is disengaged in a state of vapour. Notwithstanding, the presence of this acid is not indicated by the usual tests. Chap. V.

3. This ether is composed of Composition.

Hydrochloric acid	29·44
Carbon	36·61
Oxygen	23·31
Hydrogen	10·64
	100·00

II. OF SULPHURIC ETHER.

(Formerly called, *Vitriolic Ether.*)

1. Sulphuric ether may be prepared by distilling a mixture of equal parts of alcohol and sulphuric acid, in a retort, to which is luted a large receiver, surrounded with ice or cold water. A vapour comes over, which condenses in the receiver and runs down its sides in striæ. This condensed vapour is the sulphuric ether. It is rendered impure, however, by admixture of sulphurous acid, alcohol and water. It may be purified from the first, by mixture with a little water and a portion of lime, and a re-distillation. It may be deprived of the water, by mixture with dry pulverized carbonate of potash. The alcohol is separated by means of dry chloride of calcium (muriate of lime), which combines with it and sinks, while the pure ether remains swimming on the top. By pursuing these methods of purification, sulphuric ether has been obtained of the specific gravity of 0·632, at the temperature of 60°. Sulphuric ether; preparation.

2. Sulphuric ether is a colourless liquid, of a very fragrant smell and hot pungent taste. It is exceedingly volatile and vaporizable. When poured out in the open air, it disappears in an instant, being converted into vapour, and produces, by its evaporation, a very considerable degree of cold. If a glass vessel, containing water and surrounded with a cloth, be dipped in ether for several successive times, after it has previously evaporated, the water in the vessel will be converted into ice. This ether does not combine with water. At the temperature of 98°, in the open air, it boils; but it boils at a temperature of − 20° in a vacuum. Its freezing point is at the temperature of − 46°. The specific gravity of its vapour is 2·58. It is very inflammable; and when kindled in a state of vapour, it burns rapidly with a fine white flame. Properties.

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Composition.

3. It is composed of

Hydrogen	14·40
Carbon	67·98
Oxygen	17·62
	100·00

4. Sulphuric ether, mixed with twice its weight of alcohol, forms the *sulphuric ether with alcohol* of the Edinburgh college; formerly called the dulcified spirit of vitriol. This compound is used in the formation of some ethereal tinctures. When prepared with cinnamon and other aromatics, it forms the *aromatic sulphuric ether with alcohol* of the same college. It enters also into the composition of the anodyne liquor of Hoffman.

Elixir of vitriol.

5. The *aromatic sulphuric acid* of the Edinburgh college, usually called the *elixir of vitriol*, is, in fact, an aromatic sulphuric ether with sulphuric acid. It is formed by dropping, gradually, one part of sulphuric acid upon four parts of alcohol, and digesting the mixture in a close vessel, at a gentle heat, for several days; at the end of which time, the aromatics are added.

III. OF NITRIC ETHER.

Nitric ether; preparation.

1. Thenard has ascertained, that the liquid, heretofore considered as nitric ether, is in fact a mixture of alcohol, water, ether, nitrous and acetic acids. To obtain nitric ether pure, this chemist devised the following process: Pour equal weights of alcohol, and nitric acid of the specific gravity of 1·283, into a retort. Prepare an apparatus, consisting of five tall and narrow glass jars, half filled with a saturated solution of chloride of sodium (common salt), and connected together by means of a series of bent tubes. This connection by tubes is to be arranged in the following manner: the first tube is to pass from the top of the first jar to the bottom of the second jar; the second tube, from the top of the second jar to the bottom of the third, and so on of all the rest of the jars. The first jar is then to be connected with the retort by means of a glass tube, one end of which must be luted to the beak of the retort, and the other pass down to the bottom of this jar. The last jar is connected, by means of a tube, to the pneumatic trough. All the jars are now surrounded by a mixture of chloride of sodium (common salt) and snow, to keep them as cold as possible. A moderate heat is then applied to the retort. What gases become formed by the action of the heat, pass through the different solutions to the water trough. The ether itself is deposited in the different jars, and swims on the surface of the contained solutions. It is then separated, and may be

freed from nitrous and acetic acids by agitation, in a close vessel, with carbonate of lime (chalk), until vegetable blues are no longer affected by its action.

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Properties.

2. Nitric ether, when thus obtained, is a liquid, having a slightly yellow colour, and a very strong ethereal odour. Its taste is peculiar and strong. It is somewhat heavier than alcohol, and much more volatile than sulphuric ether. It is but sparingly soluble in water, but dissolves in alcohol in every proportion. It burns brilliantly with a white flame, like sulphuric ether. When kept for some time or heated, or when agitated with water, both nitrous and acetic acids become formed. It is liquid at the temperature of 70°, and when the barometer stands at 30 inches; but if the heat be increased beyond this temperature, or the barometrical pressure lessened, it assumes the form of a vapour.

Composition.

3. It is composed of

Oxygen	48·52
Carbon	28·45
Azote	14·49
Hydrogen	8·54
	100·00

The above is an analysis performed by Thenard. It does not agree well with the atomic theory. It is perceived that this ether differs from other ethers in containing azote as a constituent.

Nitrous ether, an impure nitric ether.

4. The nitrous ether of the Dublin college is an impure nitric ether. It is formed by pouring a mixture of alcohol and sulphuric acid upon dry and coarsely powdered nitrate of potash (nitre), placed in a retort. The retort is furnished with a receiver, which must be kept cool by means of water or snow. No artificial heat is requisite to produce the proper degree of action.

Sweet spirit of nitre, a mixture of nitric ether and alcohol.

The spirit of nitrous ether (sweet spirit of nitre) may be considered a mixture of nitric ether and alcohol. It is formed by distilling a mixture of one part of nitrous acid of the shops and three parts of alcohol, by the heat of boiling water, into a receiver kept cool by cold water or snow. The mixture of the acid and alcohol is made by adding the former by degrees to the latter, contained in a capacious phial immersed in cold water, and agitating the whole at every addition. The mixture must then be kept for seven days, before it is exposed to heat.

Its medical properties.

Spirit of nitrous ether constitutes a very valuable medicine. Its chief property is that of a stimulating diaphoretic; which fits it for exhibition in the latter stages of fevers, where the skin remains dry, and the febrile action has begun to abate.

SECTION III.

OF VOLATILE OILS.

1. There are a great number of these substances. It is not intended, however, to give an account of each of them individually; their general characters only will be noticed.

General properties of volatile oils.

2. Volatile oils may be distinguished by the following general properties. They are usually liquid; but sometimes they have the consistence of butter. Their taste is acrid, and their smell, strong and fragrant. They are volatilized by a heat under 212°. They are soluble in alcohol, and but imperfectly so in water. When dropped upon paper and exposed to a gentle heat, they evaporate entirely without leaving a greasy stain. This last circumstance, particularly, distinguishes them from the fixed oils.

3. Volatile oils are almost all obtained from vegetables; and from every part of the plant, except the substance of the cotyledons. On the contrary, the fixed oils are generally contained in these portions of the plant.

Method of obtaining them.

4. Sometimes volatile oils are obtained by simple expression; but, in general, they can be extracted only by distillation. The method is to put the part of the plant, containing the oil, in a still with water, and to apply a gentle heat: the volatile oil is driven over with the water, and is found swimming on its surface.

5. The specific gravity of the volatile oils is very various. Most generally, however, it is below that of water. The point at which different volatile oils congeal varies very much also. Oil of anise and of fennel become solid at 50°, and oil of turpentine begins to melt at 14°. Several volatile oils require a cold as low as $-17°$ for their congelation.

Effects of exposure to air.

6. When volatile oils are exposed to the open air, their colour gradually deepens, their odour diminishes, and they become more viscid. By long exposure, they at last assume the appearance of resins. When sufficiently heated, they take fire and burn with a clear bright flame, emitting a vast quantity of smoke. The products of their combustion, besides the soot, are water and carbonic acid.

Action of chlorine upon them.

7. Volatile oils, by the action of chlorine, are converted into a yellow resinous substance. Oil of turpentine, in a state of vapour, passed through a glass tube along with this supporter, combines with it, and forms a thick, heavy, white oil, which sinks immediately in water, and has a taste and smell resembling that of nutmegs.

They dis-

8. Volatile oils dissolve a portion of sulphur. When di-

gested upon this substance, at the temperature at which it melts, they dissolve a portion of it, and acquire a brown colour and a disagreeable taste and smell. These combinations are called balsams of sulphur. Volatile oils also dissolve a small portion of phosphorus at a digesting heat, but they deposite it again as they cool. They are all more or less soluble in alcohol, ether, and the fixed oils.

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solve sulphur and phosphorus.

9. Sulphuric acid acts with considerable energy upon the volatile oils. It first dissolves them, then converts them into a substance of a resinous nature, and ultimately into charcoal. Hydrochloric acid has much less action upon them than sulphuric acid: it combines with the oil of turpentine, and forms a compound very similar in appearance to camphor. Nitric acid, when thrown upon them suddenly in a concentrated state, generally sets them on fire; but when sufficiently diluted, it effects their solution, and converts them into a yellow substance, resembling resin.

Action of the stronger acids upon them.

10. Volatile oils are found to consist of hydrogen, carbon and oxygen, united in various proportions; but no exact analysis has been made of them.

11. Some of the volatile oils are used in the arts. They give to different perfumes their odorous properties. The oil of turpentine is used to dissolve resins, which are afterwards employed as varnishes and for many other purposes.

Their uses in the arts;

12. A great many volatile oils are employed in medicine. Their chief use is to conceal the taste of the more nauseous medicines, by substituting an agreeable pungency. In many cases, the medicinal virtues of the substances, from which they are obtained, are preserved in the oil itself. Thus it is found that the oil of juniper berries is diuretic; that of scurvy-grass, antiscorbutic; that of mint, stomachic, and so of many others. The most important volatile oil, in a medical point of view, is the volatile oil of turpentine (spirit of turpentine). It is obtained by distilling the common oil of turpentine along with water. Its principal properties are those of a diaphoretic and diuretic. When given in large doses, it operates with great power upon the urinary organs. This oil certainly deserves more attention than is generally bestowed upon it by the practitioners of the United States.

and in medicine.

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SECTION IV.

OF FIXED OILS.

General properties of the fixed oils.

1. The fixed oils have the following general properties: they are usually liquids, possessing a certain degree of viscidity, and having an unctuous feel and mild taste. They are very combustible, and are insoluble in water, and nearly so in alcohol. Their boiling point is above 600°. When dropped upon paper, they leave a greasy stain, which is not removed by exposure to a gentle heat.

2. Fixed oils are obtained from both animal and vegetable substances by simple expression. They are all lighter than water; but they differ from one another in the degree of their specific gravity.

Their combustion described.

3. Fixed oils, in a state of vapour, catch fire on the approach of an ignited body, and burn with a yellowish-white flame. It is on this property of the fixed oils, that the burning of lamps and candles depends. By the approach of an ignited body to the wick, it catches fire; and sufficient heat is thereby produced to convert a portion of the tallow or oil into vapour, which immediately takes fire in the wick. The heat thus generated is sufficient to convert a fresh portion of the tallow or oil into vapour, which in its turn inflames. In this manner, the flame is preserved as long as any tallow or oil remains. The products of this combustion are water and carbonic acid.

4. All the fixed oils, which are liquid at the common temperature of the atmosphere, lose their liquidity when exposed to a sufficient degree of cold; but the congealing points of different oils are exceedingly various.

Divided into drying oils and fat oils.

5. All the fixed oils, when exposed to the air, gradually absorb oxygen, become more and more viscid, and are at last converted into solids. Some oils, after having undergone this change, remain transparent, while others become opaque like tallow. Those which remain transparent are called drying oils; while those which become opaque are denominated fat oils.

Oils may be made drying artificially.

Manner in which this is done.

6. Most of the fixed oils may be converted into drying oils by artificial management, and are thereby rendered fit for use by the painter and varnisher. The management consists in boiling the oil for some time in an iron pot. It thereby acquires a deeper colour and greater consistency, owing to a partial decomposition; there being abundance of watery vapour and hydroguret of carbon separated during the boiling. For some purposes, the oil is set on fire and

allowed to burn for some time, when it is extinguished by covering the vessel in which it is contained; after which the boiling is continued, until the oil acquires the necessary viscidity, and loses, in a great measure, its unctuous qualities. It is common also, in many cases, in forming the drying oils, to boil them with a portion of the semi-vitrified oxide of lead (litharge). The change which takes place in oils, whereby they are rendered drying, is not well understood.

7. The fixed oils dissolve a small portion of phosphorus by the assistance of heat. They dissolve readily a portion of sulphur, by the same agency. The solution formed is of a reddish colour, and when allowed to cool, deposites the sulphur in crystals.

Fixed oils dissolve phosphorus and sulphur.

8. The fixed oils are insoluble in water. When agitated with water, the mixture assumes a milky appearance; but upon rest, the two liquids gradually separate, the oil swimming above the water. If a mucilaginous substance, such as gum arabic, be incorporated with the mixture, it becomes a kind of bond of union to the oil and water, which now constitute a permanently milky compound. These mixtures of oil and water, by means of mucilage, are called emulsions. When oily seeds, such as almonds, are triturated with water, the same kind of mixture is formed; because, in these seeds, a mixture of oil and mucilage exists ready formed.

They are insoluble in water;

9. Most of the fixed oils are but sparingly soluble in alcohol. This liquid takes up very little olive or almond oil, but somewhat more of linseed oil; whereas it dissolves any quantity of castor oil. In general these oils are more soluble in sulphuric ether than in alcohol. Like alcohol, sulphuric ether dissolves any quantity of castor oil.

and but sparingly soluble in alcohol.

10. The fixed oils unite readily with the alkaline and earthy salifiable bases, and form compounds called soaps. But it would appear, that they do not unite with these bodies as oils, but undergo a singular change, at the moment of saponification, which will be explained hereafter. They also combine with salifiable bases of the third class, commonly called metallic oxides, and form compounds called plasters.

They unite with salifiable bases.

11. The action of acids upon the fixed oils has been but very imperfectly ascertained. Sulphuric acid acts upon them with considerable energy; they are at first converted into a black substance resembling bitumen; but if the action of the acid be allowed to continue long enough, they are ultimately entirely decomposed into water, charcoal, and an acid. Nitric acid has a more powerful action upon them.

Action of acids on fixed oils.

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When poured suddenly upon the drying oils, they are set on fire. The same effect is produced upon the fat oils, if the nitric acid employed be previously mixed with a portion of sulphuric acid. Nitric acid, sufficiently diluted, converts the drying oils into a substance like resin, and fat oils into a mass resembling tallow.

Rancidity explained.

12. Fixed oils, upon keeping, are liable to undergo a change, which is known by the name of rancidity. They become thick, and acquire a brown colour, an acrid taste, and a disagreeable smell. It is generally supposed that this change depends upon the presence of mucilaginous matter, which many oils when newly extracted contain; but how this matter acts is not known. It is ascertained, however, that an acid is generated during the conversion; since rancid oils have the property of changing vegetable blues to red.

Fixed oils useful in pharmacy.

13. The fixed oils are of indispensable use in pharmacy. Under the forms of tallow, mutton-suet and hogslard, they constitute the basis of all kinds of ointments and plasters. Among the most useful of them are the olive and castor oils. The latter furnishes the physician with an excellent mild purgative.

Ultimate constituents of fixed oils.

14. The fixed oils are compounds of hydrogen, carbon and oxygen, united in various proportions. The only fixed oil which has been accurately analyzed is the olive oil. Its constituents were ascertained by Gay-Lussac and Thenard, by burning a determinate quantity of it, mixed with chlorate of potash. They are

Hydrogen	13·360
Carbon	77·213
Oxygen	9·427
	100·000

The above analysis is given without reference to the atomic theory, with which it does not well accord.

Proximate constituents of all fixed oils are two peculiar substances, called *steärin* and *elaïn*.

15. The constituents just stated for the fixed oils may be called their ultimate constituents. Besides these, by a peculiar mode of analysis, they may be resolved into two distinct substances, which may with propriety be called their proximate constituents. These substances were discovered by Chevreul in 1814, as the proximate constituents of all kinds of animal fat; and in the succeeding year, Braconnot proved that a similar constitution obtained in the fixed oils of the vegetable kingdom. An account of these two substances, under the names of *steärin* and *elaïn*, appellations assigned to them by Chevreul, will form a very proper sequel to the present section on the fixed oils.

I. OF STEÄRIN.*

1. This substance may be obtained by treating purified hogslard with boiling alcohol. As the alcohol cools, a white crystalline substance is deposited, which is steärin. Steärin; how obtained by Chevreul.

2. Hogslard, being an animal fat, is composed, as has been already mentioned, of steärin and elaïn; the former is soluble in boiling alcohol only; the latter, in alcohol whether hot or cold. It is on this account, that the steärin is obtained in a separate state by the process just given; for the alcohol, upon cooling, is no longer able to hold in solution the steärin, which is therefore deposited, while the elaïn still remains in solution.

3. The above method for obtaining steärin is that of Chevreul. Braconnot employs a simpler one. It consists in this: if the oil to be analyzed is in a liquid state, it is first congealed, and afterwards subjected to strong pressure between the folds of blotting paper. The elaïn is imbibed by the paper, while the steärin remains behind pure. The concrete oils may be subjected to pressure at once, without any previous preparation. Method of Braconnot.

4. Steärin, when thus obtained, is a white, brittle substance, having some resemblance to wax. When pure, it is destitute of smell or taste. It does not alter the colour of vegetable blues. It is somewhat different in its properties, according to the animal oil from which it may be obtained. Properties of steärin.

II. OF ELAÏN.†

1. Chevreul's process for obtaining elaïn is to dissolve tallow of some kind in boiling alcohol, to allow the steärin to precipitate by cooling, and to distil the alcohol from the elaïn. Braconnot obtains it from the paper which has imbibed it in his method by pressure. The paper is soaked in water and subjected to pressure. The pure elaïn is thereby forced out. Elaïn; process for obtaining it.

2. Elaïn has very much the appearance of a vegetable oil. It differs considerably, according to the tallow or oil from which it may be separated. Sometimes it is obtained destitute of smell or colour; but more usually it has both, owing to the presence of foreign substances. Its properties.

The properties of steärin and elaïn having thus been briefly given, it may be worth while to state the propor-

* From στεαρ, tallow. † From ελαιον, oil.

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tions, in which these substances combine in several of the more familiar forms of fixed oil.

Proportion in which steärin and elaïn combine in several fixed oils.

Butter is composed of	steärin	40
	elaïn	60
Hogslard, of	steärin	38
	elaïn	62
Olive oil, of	steärin	28
	elaïn	72

The proportions of steärin and elaïn in a number of other fixed oils have also been ascertained.

SECTION V.

OF SPERMACETI.

Spermaceti, obtained from a species of whale.

1. This substance, mixed with a liquid oil, is found in a triangular bony cavity in the head of the spermaceti whale. It is obtained, in a separate state, by expression; in which process a very pure whale oil is at the same time separated. The residuum, after being freed from impurities by washing, melting and straining, and lastly by treatment with a weak solution of potash, is pure spermaceti.

Properties.

2. When perfectly pure, spermaceti is a beautiful white substance, of a crystalline appearance. It is very brittle, and has scarcely any taste or smell. Acids have scarcely any action upon it; but potash and soda combine with it slowly, and form a kind of soap. Hot ammonia combines with it also, and becomes converted into a liquid soap, which is not decomposed by cooling or the addition of water, but immediately upon the addition of an acid, the spermaceti being precipitated, altered in its properties. Spermaceti is altered in a similar manner when saponified by potash or soda.

SECTION VI.

OF SOAPS.

Chemical nature of soaps.

Soaps are formed by mixing fixed oils with the different salifiable bases. They may be conveniently divided into those which are soluble in water, and those which are insoluble. The latter, from their insolubility, cannot be used as detergents, and will be passed over without notice. The soluble soaps are those of ammonia, soda and potash.

I. SOAP OF AMMONIA.

(Commonly called, *Volatile Liniment.*)

1. This soap is very readily formed by mixing olive oil and water of ammonia together. The proportions directed by the Edinburgh college are eight parts of the former, and one of the latter. It is sometimes prepared by mixing two parts of olive oil with one part of water of ammonia, when a strong liniment is desired. Soap of ammonia; how formed.

2. The soap of ammonia is used, medicinally, as a stimulant and rubefacient. It is very frequently applied to the neck in inflammatory sore throat, and to different parts of the body in rheumatisms.

II. SOAP OF SODA.

(Commonly called, *Hard Soap.*)

1. This soap is prepared from the carbonate of soda (soda of commerce) and some fixed oil. Olive oil is found to answer best, and next to it, tallow. The outline of the process is as follows: Any quantity of the soda of commerce (carbonate of soda) is mixed with about one-fifth of its weight of lime, which has been previously slaked and passed through a sieve. A quantity of water is poured over this mixture sufficient to cover it, and allowed to remain for several hours. The lime attracts the carbonic acid from the soda, so that the liquid becomes a solution of pure soda. The solution is then drawn off, and two other solutions made, by allowing fresh portions of water to stand upon the residuum for two or three hours, at successive times. A quantity of oil, equal to six times the weight of the soda employed, is then put into a boiler, together with a portion of the weakest solution, and the whole subjected to boiling, with constant agitation. As the boiling continues, the whole of the third, and then the second solution of the soda are added at intervals. The mixture assumes a milky appearance, and begins to acquire some consistence. Part of the strongest solution is now added to it at intervals, the boiling and agitation being still continued. The soapy substance at last begins to separate from the watery part; at which time, common salt is to be added to render the separation more complete. After this, the mixture is still exposed to a boiling heat for several hours longer, when the fire is withdrawn and the mass allowed to cool. After a few hours' repose, the soap is found completely separated from the watery part, and swimming on its surface. The watery portion is then drawn off. Soap of soda. Preparation.

To complete the formation of the soap, it is again exposed to heat, and, to facilitate its fusion, a little weak ley is added.

As soon as it boils, the remainder of the strongest solution of the soda is added to it at intervals; and after it has acquired a proper consistency, the fire is again withdrawn, the watery part separating as before. It is then heated for the third time, mixed with a little water to form it into a proper paste, and afterwards poured into vessels and allowed to cool. In a few days, it will have acquired sufficient consistency to be formed into cakes for use.

Soda forms a soap with a variety of fixed oils.

2. Soda forms a hard soap with a great variety of oils; but it appears that linseed oil and whale oil are not proper for the fabrication of this kind of soap. Soda and tallow form a white hard soap. The common yellow soap is formed of the same ingredients, with the admixture of a considerable portion of rosin.

III. SOAP OF POTASH.

(Commonly called, *Soft Soap.*)

Soap of potash, prepared in the same way as the soap of soda.

1. When potash is substituted for soda in the formation of soap, precisely the same process is employed as for making a soap of soda. There is this difference, however, between this soap and the one last described, that it cannot be made to assume the solid form. A hard soap, it is true, may be formed from soft soap by the addition of common salt; but in this case, the soap of potash is changed into a soap of soda; the common salt being decomposed, and thereby affording soda, which displaces the potash.

The proximate constituents of fixed oils, converted into acids by saponification; the same change produced also on spermaceti.

It has already been mentioned, that the fixed oils, by combining with salifiable bases, undergo a change, which was promised to be explained hereafter. It is found, that, when these oils are saponified, their proximate constituents steärin and elaïn become acid substances. This is also true with regard to spermaceti. These facts were ascertained in 1813, by Chevreul. This chemist gives the name of

Margaric acid to steärin,
Oleic acid to elaïn, and
Cetic acid to spermaceti,
} as altered by saponification.

The present chapter upon soaps will be closed by an account of these acids.

IV. MARGARIC* ACID.

Margaric acid; how obtained.

1. This acid was obtained by Chevréul by the following process: A soap, formed by means of hogslard and potash, was treated with water, whereby part of it became dissolved, and part remained insoluble. The insoluble portion is a

* From μαργαριτης, a pearl; in consequence of its pearl-white colour.

compound of margaric acid and potash. It was decomposed, and its acid part set at liberty, by means of hydrochloric acid.

Its properties.

2. Margaric acid has a pearl-white colour. It is destitute of taste, and has a weak smell like that of white wax. It is lighter than water. It melts in a gentle heat, and crystallizes upon cooling in brilliant white needles. It reddens vegetable blues. It is capable of combining with several of the salifiable bases, and forms compounds analogous to salts.

V. OLEIC ACID.

Oleic acid; how obtained.

1. This acid was obtained by Chevreul from the soluble part of the soap of potash formed from hogslard. This part was found to be an oleate of potash. By treatment with tartaric acid, it is decomposed and its acid separated.

Its properties.

2. Oleic acid is an oily liquid, destitute of smell or colour when perfectly pure; but usually having a rancid odour, and a yellow or brown colour. It is insoluble in water, but very soluble in alcohol. It changes vegetable blues to red. It is lighter than water. Its point of congelation is various, as obtained from different saponified oils. It unites with a number of the salifiable bases, and forms compounds analogous to salts.

Margaric and oleic acids have been obtained from several saponified animal fats, and are always found to have very nearly the same properties. If Chevreul's experiments may be depended upon, then every species of soap, formed from the fixed oils, contains both margaric and oleic acids; since these are the substances, into which the proximate component parts of the oils are converted during saponification.

VI. CETIC ACID.

Cetic acid; how obtained.

1. When spermaceti is saponified by potash, and decomposed by an acid, the matter deposited is not spermaceti, but a substance resembling it, possessing acid properties. This substance, Chevreul has called cetic acid.

Its properties.

2. Cetic acid is a white solid, destitute of taste or smell. It melts at a gentle heat. It is insoluble in water, but dissolves readily in boiling alcohol. The alcoholic solution is capable of reddening vegetable blues. With some of the salifiable bases, it forms compounds analogous to salts.

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TABLE,

EXHIBITING THE ARRANGEMENT OF THE COMPOUND PONDERABLE BODIES.

- I. Salifiable Bases.
  - 1. Alkaline Salifiable Bases.
    - 1. Ammonia.
    - 2. Potash.
    - 3. Soda.
    - 4. Lithia.
    - 5. Lime.
    - 6. Barytes.
    - 7. Strontian.
    - 8. Magnesia.
  - 2. Earthy Salifiable Bases.
    - 1. Yttria.
    - 2. Glucina.
    - 3. Alumina.
    - 4. Zirconia.
    - 5. Thorina.
    - 6. Silica.
  - 3. Salifiable Bases, having neither alkaline nor
    - Under this title are included nearly all the oxides, formed of basifiable combustibles of

BOOK II.

OF IMPONDERABLE BODIES.

UNDER this title are included those substances, which cannot be weighed, or exhibited in separate and distinct masses. These bodies may be enumerated as *light*, *heat*, *electricity* and *magnetism*. Light and heat only will be noticed in this work. They will be treated of in the two following chapters. Book II. Imponderable bodies, defined and enumerated.

CHAPTER I.

OF LIGHT.

1. IT is intended to give a very cursory sketch only of the properties of light. This substance is not legitimately an object of chemical investigations, although it is concerned in a number of chemical phenomena.

2. Light is generally considered to be a substance, composed of inconceivably small particles, constantly separating from luminous bodies, and which, by entering the eye, excite the phenomena of vision. Some philosophers, however, consider light to consist in the undulations of a subtle fluid, filling all space, which, in a quiescent state, has not the power of exciting vision or of rendering bodies luminous. Properties of light.

3. The most distinctive property of light is its amazing velocity. It has been demonstrated by Roemer, a Danish astronomer, that it moves at the rate of 200,000 miles in a second. It moves with great velocity.

4. Light moves constantly in straight lines. It may be frequently made to change its direction; but every new direction will be a straight line. As long as a ray of light remains in the same medium, its direction remains the same; but if it pass obliquely from a rarer to a denser medium, it takes a new direction approaching a perpendicular line, drawn from the surface of the new medium, at the angle of incidence of the ray. But if the ray pass from a denser to a rarer medium, it is turned in a new direction It changes its direction, when entering a new medium, and is said to be refracted.

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from the perpendicular. This change in the direction of light, when it passes from one medium to another, is called its refraction. When a ray of light, passing through one medium, strikes against the surface of another with a certain obliquity of direction, it is turned back again in the same medium. This turning back of a ray in one medium, in consequence of its impinging on the surface of another medium, is called its reflection. The angle, in which the ray falls upon the new medium, is called the angle of incidence; and the angle, which it makes with the same medium after it has assumed its new direction, is called the angle of reflection. The angles of incidence and reflection are always found to be equal.

Reflection described.

Transparency explained.

5. Light, by falling upon bodies whose particles are uniformly arranged, gives rise to what is called their transparency. When light falls upon a transparent body, it passes through it in all directions without impediment. Rays of light excite the vision of the objects from which they proceed, after having passed through such bodies, nearly as well as when passing in open space. It is probable, that light is enabled to pass through transparent bodies, without restraint, in consequence of its being attracted equally on all sides, thereby not being turned out of its straight course. On the other hand, bodies are opaque, when the rays of light which enter their surfaces are irregularly attracted by their particles, whereby they are impeded and ultimately arrested in their progress. Bodies are semi-transparent, when some rays pass through them, while others are reflected from different points of their interior substance.

Causes of opacity and semi-transparency.

Light, as usually seen, compounded of seven kinds of elementary light.

6. Light, as it is generally seen, is compounded of seven different kinds of light. It may be decomposed by being passed through a triangular prism of glass. It thereby assumes the form of an oblong image, usually called spectrum, composed of seven different coloured portions, each portion produced by a different ray of light. This decomposition takes place in consequence of a difference in the refrangibility of the component parts of light. Each part, in consequence of this difference, is turned off in a direction peculiar to itself, and consequently located by itself, when arrested by the interposition of an opaque surface. These seven component parts of light, according to the colour which each excites in vision, are called red, orange, yellow, green, blue, indigo or violet light. They are enumerated in the order in which they are arranged in the spectrum, which is also the order of their refrangibility; the red light being the least, and the violet the most refrangible.

CHAP. I.

Colour explained.

7. When a compound ray of light falls upon a body, all its elementary rays may be absorbed or reflected, or part of them may be absorbed and part reflected. When a body absorbs the whole ray of light, its colour is said to be black; but, in reality, it ought to be said to have no colour, as it makes not an absolute but a negative impression on the optic nerve. When a body is white, it is in consequence of the whole ray being reflected from its surface, and entering the eye. When a body absorbs some parts of the compound ray and reflects other parts, its colour is produced by those rays, which are reflected. If the blue ray be reflected, while the rest are absorbed, the body appears blue; if the green ray, the body appears green; and if two or more rays are reflected, while the rest are absorbed, the body so reflecting will be of a colour compounded of the colour of such rays.

Effects of light on plants and metallic oxides.

8. The absence or presence of light produces very remarkable effects upon different bodies. Plants, in the open air exposed to the light of day, generally reflect the green ray of light, or are green; but if placed in a dark room, they acquire the property of reflecting the whole ray of light without decomposition, or, in other words, they become white. Similar changes take place in the ray reflected from various metallic oxides, in consequence of an exposure to an increased quantity of light.

Light separates oxygen from the latter.

9. The changes, in the colour of metallic oxides by light, are attended by a deoxidizement of these compounds. It is not known in what way this chemical decomposition takes place; but it is ascertained, that, of the different colorific rays already mentioned, the violet has the greatest deoxidizing power; and that this power decreases gradually towards the red end of the spectrum. It appears by some late experiments, that the deoxidizing power is possessed, to a still greater extent, by some rays which are found a little beyond the violet end of the spectrum. These rays are not colorific, and, from their most remarkable property, have been called deoxidizing rays.

Sources of light.

10. The sources from which light is emitted are very various. The principal ones are the sun, burning bodies, and heated bodies. The rays of the sun appear to be compounded of rays of light and rays of heat. The sun is incomparably the most abundant source of light. Bodies undergoing combustion always emit light as well as heat. Burning bodies, next to the sun, are the most abundant sources of light. All bodies, which do not previously undergo volatilization or combustion, upon being heated to a certain temperature, become luminous, or, in other words,

Book II. emit light. Thus iron, upon ignition, becomes first red and afterwards white hot. To this rule, however, there is one exception; the gases do not become luminous, in any heat to which they have as yet been exposed.

CHAPTER II.

OF HEAT.

(Chemical name, *Caloric.*)

The word heat, used in different accepta-tions.

THE word heat is used in two different acceptations. When a person speaks of feeling heat, he alludes to the sensation produced by an accession of heat to some part of his body. Heat, therefore, when spoken of with reference to sensations, is always a relative term. The sensation of cold may be said, in a philosophical sense, to be a sensation of heat; that is, a sensation of caloric or the matter of heat passing out of the body. Hence it appears, that the matter of heat is the cause of the sensation both of heat and cold; and that the difference in the impression which it produces depends alone upon the direction in which its motion is established with respect to the sentient body.

Its mean-ing in a chemical sense.

In this chapter, it is the matter of heat, or caloric which is the subject of consideration. The reader will, therefore, take care not to confound the matter of heat with its effects on sentient bodies.

The sub-ject of heat, treated of under six heads.

The subject of caloric will be treated of under the six following heads:

1. The nature of caloric.
2. The agencies, by which caloric is put in motion.
3. The different ways in which caloric tends to a state of rest, after having been put in motion.
4. The relative quantities, in which heat in a state of rest exists in bodies.
5. The changes produced by caloric upon bodies.
6. The different instruments in common use for measuring the intensity of heat.

These heads will form the titles of the six following sections.

SECTION I.

OF THE NATURE OF CALORIC.

Two opin-ions enter-tained of

1. HEAT is considered by almost all the philosophers of the present day to be a substance, composed of inconceivably small particles. Count Rumford and Sir H. Davy, how-

ever, are of opinion, that heat depends upon a peculiar motion, and is not owing to the presence of a subtle fluid, which chemists have designated by the name of *caloric*.

Chap. II. — the nature of caloric.

2. The opinion, that the phenomena of heat depend upon a peculiar fluid, and not upon a peculiar motion between the particles of bodies exhibiting such phenomena, will be adopted in the present chapter. But whether heat be an attribute of matter or a substance, the facts detailed in the following sections are not the less certain.

SECTION II.

OF THE AGENCIES BY WHICH CALORIC IS PUT IN MOTION.

All the effects of caloric depend on motion.

1. All the effects which caloric produces depend directly or indirectly upon its motion. Hence the account of the agencies by which it is put in motion is exceedingly important. If it were impossible to put caloric in motion, there would be no means whatever to ascertain its existence, so essential is motion to the active state of caloric.

Caloric exists in different bodies in different quantities; and these quantities, compared with one another, is the measure of what is called their capacities for heat.

2. Caloric exists in all bodies, and when in a state of rest, in different quantities in each. Upon whatever cause it may depend, it is however certain, that caloric, after it has attained a state of rest, has arranged itself in different proportional quantities among all bodies. Now the relative quantities of caloric, existing in different bodies, with respect to which this fluid is in a state of rest, constitute what is called the different capacities of such bodies for caloric.

The capacity of bodies for heat, changed by several causes, and these changes give rise to the motion of caloric.

3. The capacity for heat of different bodies may be changed by a variety of circumstances. If the capacity of a body be diminished, there is extricated, and put in motion in it, a quantity of caloric, which is some time in leaving such body, and in distributing itself among surrounding bodies in quotas proportional to their respective capacities, with the result of again assuming a state of rest. During such time, the body possessing more than its quota of caloric relatively to surrounding bodies, becomes what is called hot; and while the relative excess of caloric which such body contains is distributing itself among surrounding bodies, it is said to be undergoing the process of cooling. At the same time, the surrounding bodies themselves are said to be heated; that is, the absolute quantity of their heat is increased without any increase in their capacity. After some time, this heating of the surrounding bodies is not perceptible; since gradually more and more distant bodies

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assume a portion of the caloric, which has become distributable,* in consequence of a body having suffered a diminution of its capacity, the case here supposed.

4. The state of rest of caloric is destroyed, as well by an increase as a diminution of the capacity of a body. Thus, if the capacity of a body be increased, as it does not then possess its proper quota of caloric for its new capacity, the caloric of surrounding bodies no longer remains at rest, but each surrounding body furnishes caloric in proportion to its individual capacity, compared with that of the body whose capacity is increased. This motion of caloric continues, until at last the relative quantities of caloric, in the body whose capacity has been increased, and in those which surround it, become again proportional to their respective capacities, when it entirely ceases. Now this new adjustment of caloric, to suit an increased capacity in a body, cannot take place in a moment, but requires some time; and while it is taking place, the body with the increased capacity is in the state of receiving caloric from any other body presented to it; or, in other words, it is cold. But every moment, as the caloric approaches to a state of rest, such body becomes less and less cold. After the caloric has assumed a state of rest, the surrounding bodies, in the case just supposed, contain less absolute heat than at first, a fact which is very evident in the beginning even to the senses; but after the lapse of a greater or less time, so many surrounding bodies are influenced in the general tendency to make up the distributable caloric, which has become deficient by the supposition, as to render it impossible to estimate the diminished quantity in each body, or to ascertain to what degree each has become cold.

Causes of the motion of caloric are of two kinds: 1. Causes which give rise to a distributable excess of caloric in bodies. 2. Causes which render distributable heat defective.

5. The view, which is here taken of the subject, supposes, that caloric is primarily put in motion by all causes which influence the capacities of different bodies. When the capacity of a body is diminished, it possesses a distributable excess of caloric over surrounding bodies, and is said to be heated: when the capacity is increased, the distributable caloric of a body becomes defective, the body itself absorbs caloric from surrounding bodies, and is said to be cold. Hence the causes of the motion of caloric may be divided into those, which give bodies a distributable excess of calo-

* This word, as far as I know, has never been used before. It is synonymous with the word *sensible* as applied to heat; but as it suited my purposes, in describing the circumstances attendant upon the motion of caloric, better than the word *sensible*, and is in itself better calculated to keep before the mind the exact idea intended to be conveyed, than the word for which it is substituted, I have not hesitated to adopt it.

ric, and those which render their distributable caloric defective.

Causes which give rise to a distributable excess of heat are condensation, attrition and chemical changes.

6. The causes, which give bodies a distributable excess of caloric, may nearly all be referred to such as diminish capacity. These causes are *condensation*, *attrition* or *friction*, and *certain chemical changes*. Under the latter head will be included combustion.

Examples of a distributable excess of caloric produced by condensation.

7. There are many familiar instances of the agency of condensation in producing a distributable excess of caloric in bodies. A piece of iron, by repeated blows of a hammer, may be made to become red-hot. This is a case of condensation, produced by percussion; and that this condensation lessens the capacity of the iron for heat, is proved by the fact, that a piece of iron once hammered until it becomes of a maximum of density cannot be again heated by this means, unless it be previously exposed to a red heat, and thereby lessened in density and increased in capacity. The condensation of air is capable of disengaging a sufficient excess of distributable heat to produce combustion. Thus, if a piece of tinder be placed in the bottom of a syringe, and the air contained in the barrel of this instrument be suddenly compressed upon it, by quickly urging down the piston, sufficient distributable heat is evolved to set the tinder on fire. The collision of the flint and steel may be mentioned under the head of condensation. By the stroke, a piece of the steel is driven off in a condensed state, which is thereby heated sufficiently to take fire in the air. The collision of two flints produces a distributable excess of heat in the same manner; but there is this difference in the result, that the piece of flint driven off does not take fire, being incapable of combustion.

8. If the question be asked, why, by condensation, the capacity of a body for heat is decreased, it may be answered, that it probably depends upon the nearer approach of the particles composing a body. This approach increases the repulsive power of the contained caloric, which is thereby made to fly off in the form of distributable heat.

Examples of attrition as productive of a distributable excess of caloric.

9. Attrition or friction is capable of producing a distributable excess of caloric in bodies; but the manner in which it produces this excess has never been satisfactorily explained. There is found to be no condensation or chemical action produced, which might occasion a decrease of capacity. It was certain experiments, made to ascertain the quantity of distributable heat produced by friction, which induced Count Rumford to deny the existence of heat as a substance; and to conclude that all the effects attributed to the matter of heat depended entirely upon peculiar motions.

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Distributable heat produced by friction must therefore be considered, in the present state of knowledge, as an exception from the general position, that heat is thrown into a distributable state by those causes only, which decrease the capacities of bodies.

Combustion throws heat into a distributable state.

10. Combustion is by far the most usual means, employed by man, for putting caloric in a distributable state. This process appears, most evidently, to be one, in which two bodies by their union form a third, which has a capacity for heat much less than that of either of its constituents; and hence the appearance of heat in a distributable state. This theory does not explain the appearance of light in combustion: but is it not probable, that bodies may have different capacities for light as well as for heat; and that light, during combustion, may appear in consequence of the diminished capacity of the product for this fluid?

11. The action which is going on in the sun is the cause of putting a very large quantity of heat in the distributable state. Philosophers know nothing of the kind of action going on in this great luminary; but, judging from the effects it produces, there is good reason for believing, that it is analogous to that which takes place in combustion, if not absolutely the same.

Combustion has been explained in various ways.

12. Having now mentioned combustion, as one of the means by which heat may be thrown into a distributable state; it is next proper to give a short account of the most remarkable theories, which have been, from time to time, invented to explain this wonderful process.

Stahl's theory, the first of any importance

It supposed an inflammable principle to separate from the burning body.

13. All the theories, invented before the time of Stahl, appear to have been crude and unsatisfactory. The theory of Stahl was simply this: all combustible bodies agree in containing a peculiar substance, to which they owe their combustibility. This substance, Stahl denominated *phlogiston*. When a body burns, nothing takes place but the separation of phlogiston; and the light and heat which appear are mere properties of the phlogiston, when in a state of motion. The theory of Stahl was called the phlogistic theory.

14. The phlogistic theory remained for a long time to be almost universally admitted, as well because it was easily understood, as that its ingenious author supported it by many experiments and apparent proofs.

Stahl's theory modified by Priestley.

15. The first important modification, which the Stahlian theory received, was that given to it by Priestley. This chemist found, that, when a combustible is allowed to burn until it becomes extinguished in a portion of air in a close vessel, the air is altered in its properties, and is no longer

fit to support this process. To account for the change produced in air by combustion, he supposed, that the phlogiston of the combustible united with the oxygen of the air, in which the combustible was burnt. Under the influence of this theory, he called oxygen gas, dephlogisticated air; that is, air, which, by reason of its not containing phlogiston, is fit to attract phlogiston from combustibles, or, in other words, to cause them to burn. On the other hand, air, which had been altered by combustion, he called phlogisticated air; that is, air saturated with phlogiston, derived from burning bodies during their combustion. Priestley's modification of Stahl's theory changed entirely the leading features of the latter. Stahl's phlogiston produced the light and heat of combustion: Priestley's phlogiston was no sooner separated from the combustible than it combined with the air which supported the combustion. Stahl's theory required for combustion merely a combustible and a sufficient heat to commence the separation of the phlogiston: Priestley's theory, besides these prerequisites, made the presence of some body necessary to attract the phlogiston from the combustible. In Stahl's theory, one set of bodies only were concerned, namely bodies containing phlogiston: in Priestley's theory, besides such bodies, a set to attract phlogiston from the combustible were also necessary. According to Priestley, a combustible became *dephlogisticated* by being burnt; while, on the other hand, his supporters of combustion were *phlogisticated*, by having combustible bodies burnt in them.

Priestley's and Stahl's theories compared.

16. Priestley's theory appeared to leave unaccounted for the appearance of light and heat during combustion. This point Stahl attempted to explain by referring these principles to the motion of the separated phlogiston. Dr. Crawford, in order to remove this difficulty, made an addition to Priestley's theory, by supposing, that, when the phlogiston of a burning body united with the air by which the combustion was carried on, at the same moment there is separated from such air a quantity of light and heat.

Priestley's theory did not account for the appearance of light and heat in combustion.

17. The theory, as amended by Dr. Crawford, was certainly more satisfactory, as it accounted for the appearance of the light and heat of combustion; but still it contended for the existence of a substance entirely hypothetical. Phlogiston was supposed to exist by Stahl, only because the supposition was convenient for him: no succeeding chemist had proved its existence by experiment.

18. To remove this objection, Kirwan substituted hydrogen for phlogiston, and attributed to it almost every agency, which had been previously assigned to the inflammable principle. He supposed, that every combustible contained

Book II. hydrogen, and that, during combustion, hydrogen separated from the combustible and combined with the oxygen of the air.

Lavoisier's discoveries overturned the Stahlian theory in all its forms.

19. About the time that the Stahlian theory received its last modification from Kirwan, Lavoisier made known to the world his discoveries; by which he was supposed to prove, that in every case of combustion, oxygen combines with the burning body, and separates from the light and heat previously combined with it when in the gaseous state. The product is incombustible, since it is entirely saturated with oxygen, and is therefore incapable of occasioning the emission of more light or heat, by a further combination with this principle.

20. The theory of Lavoisier, called the antiphlogistic theory, very soon overturned the modified Stahlian doctrine, which had been previously almost universally admitted. Chemists with very few exceptions adopted the new doctrine, and had no longer recourse to the hypothetical substance phlogiston to explain the process of combustion.

Lavoisierian theory supposed but one supporter of combustion; namely oxygen: others however have been discovered.

21. The theory of Lavoisier, although true in the main, nevertheless has required considerable modifications to render it consistent with the light of more modern discoveries. According to Lavoisier, oxygen is the only body which is capable of supporting combustion, or, in other words, of separating from its light and heat, in the act of combining with a combustible. Subsequent experiments, however, have proved this position to be untrue; for it has been found, that several bodies, besides oxygen, combine with combustibles in such a manner as to exhibit the phenomena of combustion. Hence, therefore, instead of there being but one supporter of combustion as Lavoisier supposed, there are at least three, if not four. The discovery of a plurality of supporters does not, however, destroy the theory of Lavoisier, it merely enlarges its boundaries.

22. The reader has already been made acquainted with the division of chemical bodies, with reference to combustion, into supporters of combustion, incombustibles, and combustibles. The foundation of this division is very intelligible and need not be explained here.

Some of the details of the Lavoisierian theory, objected to by Dr. Thomson.

23. According to the theory of Lavoisier, the whole of the light and heat, appearing in combustion, is furnished by the supporter. Some very valid objections have been brought against this supposition by Dr. Thomson. This chemist has observed, that the quantity of heat evolved in combustion is always greater, the greater the proportional quantity of a supporter which combines with a combustible; but that the reverse of this is the case with regard to the

light emitted. For example, the heat evolved by the combustion of hydrogen, carbon, and phosphorus is greater, in proportion as the quantities of oxygen which they consume are greater; but the light evolved in the same process is greater where the heat is less. It is on this account, that Dr. Thomson thinks it probable, that the light which appears in combustion is derived from the combustible, while the supporter furnishes the heat. There are several circumstances which make this opinion very plausible, but it is not less certain that some others militate against it.

Doctrines of combustion, unsettled by recent discoveries.

24. After all, the doctrines of combustion, as generally received, do not appear to be entirely confirmed by more recent investigations. During certain combinations of combustibles with each other, both light and heat are emitted; and therefore the chemical action which takes place cannot be distinguished, in a philosophical sense, from combustion. This is the case in the combination of potassium or sodium with sulphur. During the combination of sulphur and copper filings, there is so much heat evolved, that the compound becomes red-hot, or, in other words, luminous. Cyanógen gas, formed of azote and carbon, an incombustible and a combustible, appears not only to be combustible, but also a supporter of combustion; for it burns in air, the products being carbonic acid and azote, and supports the combustion of potassium, which absorbs it without decomposition. Hence the cyanodide of potassium, whose ultimate constituents are two combustibles and one incombustible, is nevertheless a product of combustion.

The facts connected with the process refuse to yield to any plan of generalization.

25. It thus appears pretty evident, that the facts at present known relating to combustion cannot be arranged upon principles founded on general analogies. Chemists have discovered so many gradations in chemical action, attended by the emission of light and heat, from the most intense, as occurs in strongly marked cases of combustion, to that which is attended with but a feeble emission of these principles, that it has been difficult to determine what chemical actions are combustions and what are not. The new discoveries, however, seem to make it necessary to distinguish those chemical actions which are attended with flame, from those attended by the emission of light and heat without flame.

Difficulty of the subject.

26. Upon the whole, in the present state of knowledge on combustion, it does not appear expedient to attempt to settle any general principles to explain the process. All that can be safely asserted on the subject is, that it is chemical action attended with the emission of light and heat. The distinction of supporter of combustion and combustible

Defects of the usual

Book II. cannot properly be preserved; for by possibility every supporter may on some occasion become a combustible, and every combustible a supporter. How then is the chemist to ascertain which are combustibles and which supporters? In a philosophical sense, when oxygen and hydrogen unite, the oxygen may be said, with equal propriety, to burn in the hydrogen, as the hydrogen in the oxygen; for, without doubt, the combustion of these gases might be effected by causing a small stream of oxygen, raised to the proper temperature, to pass into an atmosphere of hydrogen. Under such circumstances, the oxygen might be said to burn in the hydrogen; but the process is in no wise different from that of burning hydrogen in oxygen; since the union takes place only where the gases are in contact. Again, a body may be incombustible with reference to oxygen, but how is the chemist to be certain, that it is so with reference to every other substance? Although it may not form a combination with oxygen with the emission of light and heat, is it impossible that it should combine with some other body with the emission of these principles? No body can, therefore, be said to be necessarily incombustible.

division of bodies, founded on combustion.

27. Whatever theory is adopted respecting combustion, this position may be assumed as certain, that, in every case of this process, quiescent heat is changed into distributable heat; or, in other words, the product is not capable of holding in a quiescent state as much heat, comparatively with other bodies, as its constituents were before undergoing the process. Now this peculiar alteration in bodies implies a decrease in their capacity. Consequently the products of all combustions must possess a less capacity for heat than the mean capacity of their constituents.

28. The consideration of combustion, as a cause of putting quiescent heat in a distributable state, being finished, the remaining causes, which have the same agency, will now be considered.

Other chemical changes, besides combustion, put quiescent heat in a distributable state.

29. Other chemical combinations, besides those which are attended by combustion, throw quiescent heat into a distributable state. These combinations generally take place between liquids, but sometimes between gases. As a general rule, it may be said, that the compound formed suffers a decrease in density. Now this is what would naturally be expected to occur; since these mixtures suffer a decrease in capacity, as is evinced by their being incapable of holding as much heat in a quiescent state as their constituents separately.

Examples of these chemical changes.

30. As instances of chemical combinations, other than combustions, in which quiescent heat is thrown into a dis-

tributable state, may be mentioned the combination of sulphuric acid and water, of alcohol and water, or of ammoniacal gas and hydrochloric (muriatic) acid gas. There are innumerable instances of this kind, occurring in almost every chemical change.

31. Before closing the account of the different means, by which quiescent heat is thrown into a distributable state, it is proper to mention electricity. This fluid, more especially when set in motion by means of the galvanic apparatus, is capable of putting, very suddenly, a great quantity of quiescent heat in a distributable state, and of causing as intense a degree of heat as can be produced by any other means. It is not possible to explain this agency on the general principles of decreased capacity. It may therefore, like friction, be considered an exception to the position, heretofore laid down, that all agencies, which convert quiescent heat into distributable heat, produce a decrease of capacity in the bodies upon which they act. **Electricity puts quiescent heat in motion.**

32. Having finished the account of the different ways, in which the quiescent heat of a body may be diminished and part of it converted into distributable heat, and thus completed the history of one of the ways by which heat is put in motion; the other way, by which heat is disturbed from its quiescent state, comes next under consideration.

33. This other way depends upon an increase of capacity in a body. After undergoing an increase of capacity, a body requires a larger share of quiescent heat, comparatively with that possessed by surrounding bodies. Hence part of the caloric of surrounding bodies is put in motion, and thereby becomes distributable; but ultimately, by combining with the body whose capacity has been increased, it becomes quiescent. This motion continues, until the caloric has adjusted itself in the body whose capacity has been increased and in surrounding bodies, in such quotas as to suit the new relation, which the capacity of the altered body bears to the capacities of surrounding bodies. In all such cases, cold is produced; since the heat of surrounding bodies is first rendered distributable, and ultimately becomes quiescent in the body whose capacity has been increased, or, in other words, all surrounding bodies yield up part of their caloric, which passes into the body whose capacity has been increased. **Heat is put in motion as a consequence of the increased capacity of a body.** **Cold always generated in such cases.**

34. All the causes of increased capacity of bodies, or, in other words, of the production of cold, appear to be chemical. Evaporation is a very powerful means of producing cold, and acts by increasing capacity. Many chemical combinations result in an increase of capacity in the compound **Causes of increased capacity in bodies are always chemical.**

Book II. formed, and consequently produce cold. These consist generally of different kinds of salts mixed with water, and are called frigorific mixtures.

SECTION III.

OF THE DIFFERENT WAYS, IN WHICH CALORIC TENDS TO A STATE OF REST, AFTER HAVING BEEN PUT IN MOTION.

Bodies are often heated in the tendency of caloric to assume a state of rest.

1. Having in the foregoing section explained the different ways in which caloric is put in motion, the subject passes, by a natural transition, to the consideration of the different modes in which it tends to a state of rest. And here it will be proper to remark, that it is from the tendency, which distributable heat has to assume a state of rest, that bodies are most generally heated. In the last section, it has been shown how heat is *primarily* set in motion, so as to become a heating cause; but an excess of distributable heat may be accumulated in many bodies, in which it is not primarily set in motion; and this depends upon no other cause than the tendency which heat, in the distributable state, has to assume a quiescent state. Thus combustion is a primary cause of putting heat in a distributable state; but there is no inherent power in a stone to produce the same effect. Nevertheless, if a stone be put in the fire, the distributable heat of the latter, in its tendency to rest, first meets with the stone and heats it; the fire is constantly parting with heat to the stone, and the stone to the hearth upon which it rests, or to the air which surrounds it. It is in this way, that bodies, which cannot originate a distributable excess of heat, are heated during the cooling process of those which can.

Heat in motion tends to a state of rest by radiation and conduction.

2. The principal ways in which heat tends to a state of rest are by radiation and conduction. The account, therefore, of the manner in which heat is radiated and conducted will comprise all that is necessary to be said in this section.

I. OF THE RADIATION OF HEAT.

Radiation explained.

1. When a body is made to contain by any means a distributable excess of caloric, one way in which this excess tends to a state of rest is by passing off in right lines in all directions from its surface. This peculiar manner of passing off of caloric from a body is called radiation.

The amount of heat given off by radi-

2. From the experiments of Leslie, it appears, that the quantity of heat distributed by radiation depends almost entirely upon the nature of the radiating surface. This phi-

losopher filled with boiling water a thin globe of bright tin, and found, that the water took 156 minutes to cool down half way from its original temperature, to that of the room in which the experiment was made. The same experiment being repeated with this variation only, that the tin globe was covered with a thin coating of lampblack, the hot water took but 81 minutes to cool to the same temperature. From this it was evident, that hot water in a tin globe cooled nearly twice as fast, when its surface was covered with a coating of lampblack, as when it was clean and bright. Nothing could exemplify more strongly the effect of surface in increasing radiation than this simple experiment.

Radiation depends upon the nature of the radiating surface.

Heat radiates in all directions from surfaces.

3. Heat distributes itself, by radiation, in all directions from the surface of a hot body; but most copiously in a direction perpendicular to the radiating surface. For example, it was found by Leslie, that, when a tin canister, filled with hot water, is presented without any obliquity to a reflector, the effect is greatest, as ascertained by a thermometer placed in its focus, and that it becomes less and less in an oblique position, according to the degree of obliquity.

4. Leslie has found, that different substances differ very much in the radiating power of their surfaces. This he ascertained by applying different substances in succession to one side of a canister, filled with hot water and placed before a reflector. The effect of each was measured by the degree of heat observed in the focus. The following are the principal results of these trials.

Radiating power of different substances.

Taking the radiating power of lampblack as	100,
that of writing paper will be	98
of crown glass	90
of ice	85
of tarnished lead	45
of clean lead	19
of polished iron	15
of tin plate	12
of gold, silver, or copper	12

5. From these experiments, it appears, that metals distribute less heat by radiation than any of the bodies tried. The radiation, however, is influenced not only by the nature of the substance, but also by the nature of the surface in the same substance. In the foregoing statement, it is seen, that the radiation of clean lead is 19, whereas that of tarnished lead is as high as 45. The smoothness of the surface of a metal being destroyed increases its radiating power. Thus, if the side of a bright tin canister produce a radiation equal to 12, by rubbing it in one direction with fine sand paper, the ra-

Book II. diating effect will be increased to 22; but when rubbed in the cross direction, the effect is somewhat diminished.

6. Radiating heat, when it falls upon different bodies, may be absorbed or reflected, or partly absorbed and partly reflected. The nature of the body and of the surface varies very much these circumstances. It has been found, that those bodies and surfaces, which have the greatest radiating power, have also the greatest absorbing power. This is what might have been expected; since it is reasonable, that the same peculiarities, which enable heat to pass out of a surface in the greatest abundance, would also enable it to pass in. On the other hand, it has been found, that the worst radiating surfaces are the best reflecting surfaces; or, which is the same thing, that the worst absorbing surfaces are best suited for reflecting.

Absorbing power of a surface directly proportional, but its reflecting power inversely proportional, to its radiating power.

Radiating heat may be refracted.

7. Radiating caloric is capable of being refracted by transparent bodies, as well as of being reflected by surfaces; and in this way, it may be very much concentrated, as well as by reflection. The radiating caloric, emitted by the sun, may be so concentrated by refraction, as to produce as powerful a heat as can be excited by any other means.

Radiation takes place in elastic media only.

8. From the experiments of Leslie, it appears, that radiation can take place in elastic media only. In common cases, the medium is atmospheric air; but as far as his experiments have gone, radiation does not appear to be influenced by the particular elastic medium in which it occurs. It, however, decreases in proportion to the rarefaction of the medium, and at different rates in different media.

II. OF THE CONDUCTION OF HEAT.

Conduction of heat exemplified;

1. If one end of a bar of iron, 20 inches long, be put in the fire, it is some time before the other end experiences any increase of heat. From this it is evident, that heat takes some time to travel through a bar of iron. This slow manner, in which heat distributes itself under the circumstances just stated, is called its conduction.

2. It is in this way that heat always distributes itself in solid bodies. In the same mode, it may be distributed through liquids and gases; but with far less celerity than by other means to be explained presently.

and explained.

3. The explanation of the conduction of heat appears to be this: whatever quantity of heat is absorbed by the exterior stratum of particles exposed to the heating cause, a proportion of it is immediately transferred to the stratum underneath: and whatever quantity of heat is thus transferred to a substratum, a proportion of it is immediately transferred to the next stratum, and so on for any number of strata within a certain limit. These transfers may be said to depend upon

It has its limit.

the affinity of the different strata for caloric; but, be this as it may, it certainly takes place upon the same general principles, that distributable heat will combine with all bodies, whose quotas of caloric are relatively defective.

This limit depends upon the quantity of caloric, which a body is capable of receiving before it changes its state.

4. The limit, which obtains with regard to the conducting power of bodies, depends upon the quantity of caloric, with which they will combine before they change their state as to aggregation. Every dose of caloric absorbed by a conducting body, excepting that which changes its state, causes an increase of temperature; but this dose, being necessary to preserve the body in its new state, becomes a necessary constituent of it. It is on this account, that almost all solids are conductors at the common temperature of the atmosphere, because they are capable of being heated without changing their state. The particular temperature, at which solid bodies cease to be conductors, is that at which they melt. Thus ice is a conductor at any temperature under 32°; but any accessions of heat, which it receives when at that temperature, cannot be conducted, since they are employed to change its state.

Heat may distribute itself by conduction in liquids.

5. Liquids are capable of conducting caloric; but it is not by the conduction of heat that they are generally heated. The heating cause is usually placed underneath a vessel containing a liquid, and its lowermost stratum is first affected. It is thereby rendered lighter than the superincumbent strata, and, from a well known law of the pressure of fluids, is made to move towards the surface. This occurrence presents, to the influence of the heat, a new stratum of liquid, which in its turn moves towards the surface for the same reason. In this way, after some time, all the strata will have presented in succession to the heating cause. Now it must be evident, that, by these intestine motions, liquids are heated in quite a different way from the mode which takes place by conduction, and much more rapidly too. It is on this account, that liquids are said to become heated principally from their property of carrying or transporting caloric. When heat is thus applied to liquids, after some time, all their particles will have combined with as much caloric as they can receive without changing their state.

Boiling explained.

When the heating process has arrived at this point, the undermost stratum of the liquid, upon receiving the smallest accession of caloric, assumes the elastic form, passes through the superincumbent strata, and is emitted at the surface in the form of a bubble. Liquids, when thus affected by the agency of heat, are said to boil.

6. The conducting power of liquids is evinced when they are heated from their surface. Under such circum-

Book II. stances, the caloric is transferred downwards from stratum to stratum, and communicates temperature, without the aid of any intestine motion.

SECTION IV.

WHEN IN A STATE OF REST, IN WHAT RELATIVE QUANTITIES HEAT EXISTS IN BODIES.

Heat exists in different bodies, at the same temperature, in different quantities.

1. As preparatory to the explanation of the manner, in which heat is put in motion, it became necessary to inform the reader, that heat, when in a state of rest, exists in very different quantities in different bodies. It is the design of the present section to bring forward the proofs of this assertion.

2. If two portions of water be taken of equal weights, one of which is heated to the temperature of 100°, and the other to that of 50°, and mixed together, their temperature after mixture will be 75°, the exact mean of the two temperatures before mixture. But if the experiment be repeated with equal weights of spermaceti oil and water, the former at the temperature of 50°, and the latter at the temperature of 100°, the temperature of the mixture, instead of being a mean of the first temperatures, will be found to be $83\frac{1}{3}$°. Consequently the water has lost $16\frac{2}{3}$° and the oil gained $33\frac{1}{3}$°; or, in other words, the superabundant heat in the water, instead of being divided equally between the oil and the water, is divided in unequal quotas between them, when it has assumed a state of rest. Now this experiment shows, that the quantum of heat, corresponding with 50 degrees of temperature for water, after having distributed itself between equal weights of oil and water at the same temperature, raises both these liquids $33\frac{1}{3}$°; but as the water receives $\frac{2}{3}$ds of this quantum of heat, and the oil only $\frac{1}{3}$d; therefore the inference is clear, that it takes twice as much heat to raise the temperature of water $33\frac{1}{3}$ degrees, as it does to raise spermaceti oil the same number of degrees.

Distributable heat adjusts itself in different quotas among bodies; and these quotas are the measures of their capacities.

3. Now it is found to be universally true, that, when any quantity of distributable heat has adjusted itself among any number of bodies, so as to have assumed a state of rest, it is very far from having distributed itself in equal quantities among them, but has entered into each body in various quotas; and these different quotas, compared with each other, are the measures of the capacities for heat of such bodies respectively.

4. Thus, if any quantity of distributable heat adjusts itself, in a state of rest, between any two bodies, in proportions as two to one; then that body, which has the double share, is

said to be double the capacity of the other. The capacity of bodies for heat is sometimes called their *specific caloric*.

5. It is reasonable to suppose, that the relative quantities of heat in different bodies are indicated by their capacities; since it is probable, that distributable heat would adjust itself in the same proportional quantities between bodies, totally deprived of their caloric, as at any particular temperature. It must not be denied, however, that some facts are rather unfavourable to this supposition.

And these capacities are the measures of the relative quantities of heat contained in bodies.

6. In many books of chemistry, a good deal is said to explain, why bodies assume an equality of temperature; but the explanation of this fact can be nothing else than to give the reasons, why heat in a state of motion tends to a state of rest. Nothing else is meant by equality of temperature between any two bodies, than that the heat which they contain is not impelled to move from either to the other. It would appear, that the general principle, upon which caloric moves after having been set in motion, is its being unequally pressed in different directions; and that this motion continues, until its cause, namely the unequal pressure, ceases.

Equality of temperature depends upon the state of rest of heat between bodies.

SECTION V.

OF THE CHANGES WHICH CALORIC PRODUCES IN BODIES.

These effects may be arranged under three heads. 1. Changes in bulk. 2. Changes in state. 3. Chemical changes.

Changes by caloric are, changes in bulk, in state, and chemical changes.

I. OF CHANGES IN BULK.

1. As a general law, it may be stated, that an accession of heat to a body increases its bulk; but to this law there are several exceptions, which will be stated hereafter.

Caloric increases the bulk of bodies.

2. The expansion produced by a given quantum of heat is very different in solids, liquids and gases. As a general rule, in the gases it is greatest, in liquids much less, and in solids least of all. All gases suffer the same expansion by the same degree of heat, supposing them placed in like circumstances. The expansion of liquids is not found to be uniform. It has been ascertained, however, that the lower their boiling point, the greater is the expansion produced by a given increment of heat. Thus the boiling point of alcohol is low, that of water higher, and that of mercury higher than either; and the expansion, produced by any given increase of temperature in these three bodies, is greatest in the alcohol, less in the water, and least of all in the mercury. It has also been found, that the rate of the expansion in-

Book II. creases, the nearer liquids are to the boiling point. The expansion of solid bodies by heat is so very small, as to require very nice instruments to measure it; but as far as experiments have gone, it appears to be equable.

Exceptions to the law of expansion by heat.

3. The exceptions to the general law of expansion by heat are, water below a certain temperature, alumina or clay, and certain substances in the act of solidification.

Water an exception.

4. When water in the liquid state, at any temperature below 40°, is exposed to heat, it gradually contracts with every increment of heat, until its temperature reaches 40°, after which it expands by every addition of heat, until it reaches the boiling point, when it changes its state. Hence at 40° and above it, heat produces its usual effect on water; but below that temperature, it contracts this liquid. So that water is at a maximum of density at the temperature of 40°; and if it be heated above or cooled below that temperature, it is expanded.

5. The final cause of water having a maximum of density above the freezing point, would seem to be to put a limit to the consolidation of this liquid in the winter season. When water in rivers, above the temperature of 40°, is exposed to causes which abstract its heat, they operate upon a stratum on the surface, and, by the abstraction of its heat, render it specifically heavier than the water underneath; it therefore sinks to the bottom. By this means, a new stratum is exposed to the operation of the cold, and sinks in its turn. This exposure to cold of successive strata continues, until the whole of the water has acquired the temperature of 40°, when it ceases. It ceases, because the uppermost stratum, being at 40°, instead of being contracted by an abstraction of its heat, is in fact expanded, and therefore cannot sink. Hence then the cold acts continually upon the same stratum, which remains immoveably on the top, and cools it down to 32°, when it freezes. If there were no maximum of density in water above the freezing point, the successive presentation of strata to the cooling cause would continue to take place, with regard to the water in rivers, until the whole liquid, from top to bottom, would be cooled down to the freezing point; at which period, the whole would be liable to freeze into a solid mass of ice. Thus it would appear, that water was formed an exception, to the general law of the expansion of liquids by heat, by the great Author of nature, to guard against the calamitous consequences to man, which would result upon the freezing of rivers in the winter into one solid mass of ice to the bottom.

Alumina, another exception.

6. Alumina seems to constitute an exception to the general law of the expansion of bodies by heat. This earthy base

undergoes a diminution of its bulk by exposure to heat. This diminution, at low temperatures, appears to depend upon the dissipation of moisture. But at high ones, it takes place also, without any sensible loss of weight, and therefore cannot be attributed to this cause. At high temperatures, it probably contracts in consequence of its particles being urged into closer contact, so as to leave no interstices. It is not unlikely, that after fusion it may expand by heat as other bodies.

Bodies, which crystallize upon cooling, expand.

7. Although several substances expand upon freezing, and seem to be exceptions to the general law under consideration, yet upon a nearer view of the subject, perhaps, the reason of the apparent exception may be explained upon different principles, without interfering with the general law. All the bodies, which expand under such circumstances, are such as assume the crystalline form. May it not reasonably be supposed, that in crystallization their particles may arrange themselves, so as not accurately to fill space; and if so, the particles themselves might be diminished in bulk, while their aggregate, including the interstices, would take up more bulk than at first.

Instances of expansion by crystallization.

8. The most remarkable instances of this kind of expansion occur in the congelation of water, and during the consolidation of several of the metals. The force, with which water expands in the act of freezing, has been ascertained to be very great. Bombs, filled with water and plugged, have been known to be burst asunder on being exposed to a hard frost, in consequence of the freezing of the contained water. Of all the metals tried with a view to this subject, but three were found to expand upon solidification, namely, cast iron, bismuth and antimony.

9. In all cases, in which liquids, in becoming solid, assume the crystalline form, the change of state is accompanied by expansion; on the other hand, when the change takes place without being attended by any regularity of arrangement in the particles of a body, contraction is the consequence. Instances of the latter kind are furnished in the congelation of oils, and of some of the metals, particularly mercury. This latter metal is found to lose $\frac{1}{23}$d of its bulk in the act of congelation.

II. OF CHANGES OF STATE PRODUCED BY CALORIC.

Bodies occur as solids, liquids, or gases.

1. All bodies, as far as they are known, occur in one of the three following states, as solids, as liquids, or as elastic fluids or gases; nevertheless, in whichsoever state they occur, they are all capable or presumed to be capable to assume the other two, by the addition or subtraction of heat. Thus

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Some bodies may be made to assume the three states.

sulphur at common temperatures is in the solid state; but when heated to the temperature of 218°, it becomes liquid, and at a heat of about 570°, it becomes an elastic fluid or gas. Again, water at ordinary temperatures is a liquid; but when heated to 212°, it becomes an elastic vapour, and when cooled to 32°, a solid in the form of ice. Gases, at common temperatures, are not susceptible of becoming solid by an abstraction of heat; one of them, however, (ammoniacal gas) is capable of being condensed into a liquid, by a cold of −45. Hence the presumption is, that every species of air might be condensed into a solid, if chemists had it in their power to produce a sufficient degree of artificial cold.

2. When solids are converted into liquids by an addition of heat, the change takes place either instantaneously or gradually; and there appears to be a good deal of difference in the manner, in which the liquefaction is produced in these different ways. It begins to occur, in all common cases, when the solid body contains a certain quantum of heat, or, in other words, is of a particular temperature.

Water, converted into a solid at 32°; but may be cooled below that point without losing its liquid form. When it freezes it rises to 32°.

3. Water, in common cases, is converted into ice at the temperature of 32°; but, by peculiar management, it may be cooled considerably below this temperature without losing its liquid form. This peculiar management consists in having the water perfectly pure and free from air, and in exposing it to a gradually decreasing temperature. Under such circumstances, it may be cooled down to the temperature of 22° without freezing; but if a small piece of ice be thrown into it, or if it be made to take on a tremulous motion, part of it suddenly freezes, and the temperature of the whole immediately rises to the freezing point.

Inferences to be drawn from these facts.

4. The facts stated in the foregoing paragraph prove, that, when water cooled down below the freezing point is made to freeze, the part frozen, at the moment of its solidification, gives out sufficient heat to raise itself, and the remainder of the water, yet in the liquid state, to the temperature of 32°. Hence the general fact may be deduced, that, although the abstraction of heat puts water in a condition to solidify, yet, in the act of freezing, heat is given out, not as the cause but as the effect of this act; or, in other words, part of the quiescent heat of water is converted into distributable heat, by the energy of the power which induces its congelation.

Ice, during melting, receives heat, but no increase of temperature.

5. If a piece of ice be brought into a warm room, the quiescent heat of surrounding bodies is thrown into a distributable state, in its tendency to give the ice its proper quota of caloric. The caloric, however, which the ice receives, is not distributable to bodies at the temperature of

32°, in other words, does not warm the ice; but combines with it and converts it into water. As soon as all the ice is in this way dissolved, the water obtained is exactly of the same temperature with that of the ice, from which it was formed. But as it has been receiving a large share of heat during its formation, this inference may be fairly drawn, that, when caloric is in a state of rest with respect to water and ice, water contains a larger quantity of caloric than ice; or, to express the same idea in other words, when ice liquefies, it combines with heat in such a way as to render this fluid non-distributable. Water must, therefore, have a greater capacity for heat than ice.

6. What has just been said, respecting the manner in which water solidifies and ice melts, is equally true with regard to every liquid, which can become solid, and every solid capable of liquefaction. It may, therefore, be laid down as universally true, that, whenever liquids solidify, quiescent heat is converted into distributable heat; and whenever solids liquefy, it is in consequence of an accession of heat, which becomes non-distributable in them.

The quantity of heat which changes its state in the freezing of water and melting of ice, how ascertained.

7. Chemists have not only been able to deduce this general law respecting all liquids and solids, but have actually ascertained by experiment the quantity of heat, which changes its state during the freezing of water or the liquefaction of ice.

8. For example, if equal quantities of pounded ice at 32° and water at 172° be mixed together, the ice instantly melts, and the temperature of the mixture is found to be only 32°. The difference between the temperature of the ice and of the water before mixture is 140°. Now the whole of this heat is put in motion, and converts the ice into water, in which it exists in a non-distributable state, as it has not raised its temperature. From this experiment, it is concluded, that, when ice liquefies, 140 degrees of heat are reduced to a non-distributable state; that is, to a state in which they no longer affect the thermometer.

9. When the foregoing experiment is repeated with two portions of water of equal weights, one portion at 32° and the other at 172°, the result is widely different. The temperature of the mixture is found to be an exact mean of the temperatures of the two portions of water before mixture; for here the heat, which enters the water at 32°, does not become non-distributable, but gradually raises its temperature, and assumes a state of rest only, when half the excess of the heat contained in the hotter portion has entered the colder.

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Explanation of the fact, that water cooled down below the freezing point, when it freezes, gives out just so much heat as to produce the freezing temperature.

10. The fact has already been mentioned, that, when water cooled down below the freezing point is made to freeze, just so much heat is thrown into a distributable state, as is sufficient to raise the temperature of the ice formed and of the remaining water to the freezing point. If the question be asked, why the quantity of heat thrown out is exactly sufficient to raise the whole to the freezing point, the true answer perhaps is, that it could not be less, because the whole of the water in a freezing condition would not be frozen, and it could not be more, compatibly with any congelation at all. Hence it is, as Dr. Thomson has proved by experiment, that the quantity of ice formed by agitation in water, cooled down below the freezing point, bears a constant ratio to the previous coldness of the liquid; since the colder the water, a greater quantity of ice may be formed, without the evolved caloric being sufficient to raise the temperature of the whole above the freezing point. Dr. Thomson has found, that, when water is made to freeze after being cooled 5° below the freezing point, the quantity of ice formed amounts to $\frac{1}{28}$th part of the whole; when cooled down 10° below the same point, the ice amounts to $\frac{1}{14}$th part, or twice as much. Hence this chemist has inferred, that, for every 5° of diminution of temperature below the freezing point, $\frac{1}{28}$th part of water freezes suddenly by agitation; and consequently, that if a portion of water could be cooled down below the freezing point 28 times 5°, or 140°, upon agitation, the whole of it would be suddenly converted into ice of the temperature of 32°; in other words, its temperature would be suddenly raised 140°. Thus the reader perceives, that the same quantity of heat becomes distributable or capable of affecting the thermometer by the freezing of water, as is rendered non-distributable by the melting of ice.

Manner in which water freezes explained.

11. It may be curious to inquire, in what peculiar manner heat leaves water with the effect of making it solidify. It cannot be, that, when water is at the freezing point, the cooling cause acts exclusively upon a small portion of it, and converts it into ice by abstracting 140° of caloric: by no means; for the 140° of caloric, which appear when water is converted into ice, is the consequence and not the cause of its freezing. It appears to me, that the phenomena, which take place in the freezing of water cooled down below the freezing point, furnish the basis for a true explanation; since it is reasonable to suppose, that, during the ordinary freezing of water, the same happens on a small scale, which occurs in these other cases on a large one. When water is cooled down to the freezing point, it must suffer

a small decrease of temperature before it can freeze. Now I suppose, that, when the first portion of ice is formed, it is exactly so much, as is sufficient, by means of the heat it gives out in the freezing act, to raise the whole (both water and ice) to the freezing point. If the cooling cause continue to act, the temperature of the remaining water, sinks again, and again so much ice is formed, as is sufficient, by its heat evolved, to raise the whole once more to the freezing point. In this manner, by the water repeatedly falling below the freezing point, and being as often raised to the same point, by heat evolved during the freezing of a portion of it, the whole at last becomes converted into ice. This explanation would seem to be much more consistent with facts than the one, which insists upon the evolution of distributable heat, during freezing, sensible to the thermometer, while standing at the freezing point.*

Manner in which ice melts explained.

12. By a similar mode of reasoning, the manner in which ice melts may be explained. The ice, at the freezing point, receives a small increment of temperature; and, at the same moment, so much of it melts, as is sufficient, by the heat which is necessarily absorbed, to reduce the whole again to the freezing point. The ice receives another small increment of heat, and, by the melting of another small portion of it, is again reduced to the freezing point. By a repetition of these small risings and fallings in temperature, the whole at last becomes dissolved.

13. All that has been said of the conversion of solids into liquids and the contrary, by the addition or abstraction of heat, is equally applicable to the conversion of liquids into vapours, and the condensation of the latter into the former.

Distributable heat, changed into quiescent heat during the conversion of water into steam.

14. With respect to water, chemists have been enabled to ascertain by experiment, how much heat, previously in a distributable state, is rendered quiescent and not sensible to the thermometer by its conversion into steam. One of the most intelligible experiments, by which this quantity is estimated, is the following: By means of pressure, in a machine called a Papin's digester, water may be heated to the temperature of 400°, that is 188° above the boiling point. This becomes practicable, in consequence of the pressure preventing the formation of steam, by which alone, in ordinary cases, water is prevented from becoming hotter than the boiling temperature. If the mouth of the digester, containing the water thus heated, be suddenly opened, about $\frac{1}{5}$th of it immediately escapes in the form of steam, which ne-

* It is asserted that a delicate thermometer, suspended over water while in the act of freezing, is capable of indicating this evolution of heat by the rise of the mercury.

Book II. cessarily has the temperature of 212°, and the remainder immediately falls in temperature to the boiling point. Now the ⅕th of the water, converted into steam, at the moment of its conversion, contained 188° of heat, which, after its conversion, are no longer sensible to the thermometer, as it indicates the temperature of 212° only; but, besides these 188° of heat, the steam formed has rendered non-distributable 188°, received from each of the remaining fifths of the water, or four times 188°, equal to 752°; which, added to the 188°, which the steam, before its conversion, had contained in a distributable state, will give 940° of heat, thrown into a non-distributable state by the conversion of water into steam.

The quantity thus rendered non-distributable amounts to nearly 1000 degrees.

15. By other experiments, the quantity of heat, which becomes non-distributable during the conversion of water into steam, is indicated to be above 1000°. The calculation by Lavoisier makes it about 1000°. Upon the whole, while results remain thus discordant, the quantity may be taken at 1000° without any sensible error.

Dr Black first explained the manner in which heat becomes non-distributable in liquids formed from solids, and in vapours formed from liquids.

16. The reader has now been put in possession of the leading facts, ascertained respecting the changes of state, which caloric undergoes during its agency in the conversion of solids into liquids, and liquids into elastic fluids. It is proper now to inform him, that, for their discovery, and for the proper conclusions to be drawn from them, chemistry is indebted exclusively to the sagacity of Dr. Black. This chemist designated the heat, which becomes non-distributable during the change of state of a body, *latent* heat, on account of its lying hid as it were, and thereby not influencing the thermometer. He supposed that it became chemically combined with a body after its change.

Absolute caloric of bodies, calculated by Dr. Irvine.

17. It has already been mentioned as probable, that liquids have a greater capacity for heat than the solids, from which they are formed by the agency of caloric. The same reasons, which make this probable, concur to create a belief, that vapours have a greater capacity than the liquids from which they are obtained by the same agency. This appears to have been the opinion of Dr. Irvine of Glasgow, who also supposed, that the capacity of bodies for heat remained the same at all temperatures. These two opinions taken for granted, he proposed to found upon them a calculation to determine the absolute quantity of heat in bodies, as measured by degrees of the thermometer. To apply his method of reasoning to the case of water, he supposes, that the numbers which express the capacities for heat of water and ice, express also the ratio of their absolute calorics; and as the capacity of the former to that of the latter is as 10 to 9,

therefore, the quantity of heat in water at 32° is to that in ice at the same temperature, as these numbers are to each other; or, which amounts to the same thing, water, in the act of freezing, gives out $\frac{1}{10}$th of its heat; but this tenth of the heat of water is ascertained to be equal to 140°, therefore, the whole of its heat must be equal to 140×10, or 1400°.

Dr. Irvine's data, not proved.

18. The plan, upon which Dr. Irvine's calculation is conducted, is unquestionably correct in itself; but the data upon which it is founded are far from being certain. Some experiments, indeed, seem rather unfavourable to the idea, that the capacity of a body for heat remains the same at all temperatures. Dr. Irvine supposed also, that, when a body changed its state, its capacity was altered, and heat consequently either given out or absorbed. Thus, when water is converted into steam, heat is absorbed, or rendered non-distributable, because steam has a greater capacity for heat than water. But the absorption of the heat cannot be accounted for, by saying, that steam has a greater capacity for heat than water; for the question arises, what converts the water into steam? It cannot be answered, *heat;* since this would amount to saying, that water becomes steam because it absorbs heat; and water absorbs heat because it becomes steam. All that can be safely said is, that, at a particular temperature, water so combines with a certain quantity of heat, as to render it non-distributable; and that this peculiar combination of water and heat results in the formation of an elastic fluid, of greater capacity than water, namely *steam*.

III. OF CHEMICAL CHANGES PRODUCED BY CALORIC.

Heat produces many chemical changes.

1. Very few words will be said under this head. It is mentioned for the sake of precision in the classification of the subject. The reader is already acquainted with the fact, that heat constitutes the most powerful means of analysis in the hands of the chemist; since it has been evinced at every step in the progress of the present work. Heat is supposed to produce decompositions, by altering the relative intensities of affinities. It assists combination, by diminishing the force of cohesion in the particles of homogeneous bodies.

SECTION VI.

OF THE DIFFERENT INSTRUMENTS IN COMMON USE FOR MEASURING THE INTENSITY OF HEAT.

Instruments for measuring heat are

The instruments, which it is proposed to describe in this section, are the *common thermometer*, *Leslie's differential thermometer*, and *Wedgewood's pyrometer*.

1. Common thermometer.

I. OF THE COMMON THERMOMETER.

1. The thermometer is an instrument, composed of a tube of glass, blown at one end into a bulb, partly filled with mercury and hermetically sealed. When it is plunged into a hot body, the mercury expands and rises in the tube; when put in contact with a cold body, it contracts and falls. In order to measure the expansion, the tube is divided into equal parts called degrees.

2. The thermometer was invented about the beginning of the seventeenth century. The invention is attributed by some to Sanctorius. Science, however, is indebted to Newton for the method of making thermometers, which might be compared with each other.

Thermometers must have fixed points on their scales.

3. Thermometers, to answer the purpose of comparison, must have certain fixed invariable points in their scales. The temperature, at which ice melts, and water boils under a given pressure of the atmosphere, is invariably the same; these temperatures, therefore, are taken as the fixed points, and the scale is graduated in different directions from them. When a thermometer is ready for graduation, it is plunged into melting snow or ice, and the point at which the mercury stands in the tube is marked on the glass. It is afterwards plunged into boiling water, and the new point at which the mercury rests is also noted. The space between the freezing and boiling points, thus obtained, is then divided into a convenient number of equal parts called degrees.

4. Different nations have followed different plans in the graduation of thermometers, but, in all of them, the freezing and boiling temperatures of water are the fixed points in the scale. There are four mercurial thermometers in common use in various parts of the world, differing in no other respect than in the manner of their graduation.

Thermometer of Fahrenheit;

5. In Fahrenheit's thermometer, the space between the freezing and boiling points is divided into 180°; but the beginning of the scale is fixed at 32° below the freezing point, at the temperature produced by mixing together snow and common salt. Hence the freezing point is marked 32°,

and the boiling point 212°. This thermometer is used in Britain and the United States. Chap. II.

6. In Celsius's thermometer, the space between the freezing and boiling points is divided into 100°, the freezing point being placed at zero, and the boiling point at 100°. This thermometer is used in Sweden, and has been employed in France since the revolution, under the name of the centigrade thermometer. of Celsius;

7. In Reaumur's thermometer, the scale begins at the freezing point, and the boiling point is marked 80°. This thermometer was used in France before the revolution. of Reaumur; and

8. In De Lisle's thermometer, the space between the boiling and freezing points is divided into 150°; but it differs in this particular from all other thermometers, that its graduation begins at the boiling point, which is marked 0, and increases towards the freezing point, which stands at 150°. This thermometer is used in Russia. of De Lisle.

II. OF LESLIE'S DIFFERENTIAL THERMOMETER.

1. This thermometer consists of a glass tube, bent in the form of the letter U, and terminating at each extremity in a hollow bulb of the same size. The tube is partly filled with sulphuric acid, tinged red by carmine. Both bulbs are allowed to be full of air, and communicate with the tube. To one leg of the instrument, an ivory scale is affixed, divided into 100 equal parts, the zero of which is made to correspond to a point of the tube, a little above the bend. The other leg is left bare, and the ball, belonging to it, is called, by way of distinction, the focal ball. Before the glass is sealed, the sulphuric acid is so disposed, as that its upper surface may stand opposite to zero of the ivory scale. Now it is evident, that, if this instrument be placed in any situation, in which both the balls are exposed to the same temperature, the sulphuric acid will not move in the tube, since it is pressed equally in contrary directions by the air contained in the balls. But supposing, that the focal ball be exposed to a temperature higher than that which influences the other ball, then, by a necessary consequence, the sulphuric acid is pressed towards the colder ball, and rises in the leg to which the scale is attached, proportionably to the excess of temperature of the focal ball over that of the other ball; and this rise is measured by the divisions marked on the ivory scale. This instrument, it must be obvious, is well suited for ascertaining an accumulation of heat at a particular point, which does not extend to the surrounding atmosphere, as happens in the focus of a reflecting mirror; and it was by means of it, that

2. Leslie's thermometer; how constructed.

Uses of this thermometer.

Book II. Leslie was enabled to make such precise observations upon the radiating and reflecting powers of different bodies.

III. OF WEDGEWOOD'S PYROMETER.

3. Wedgewood's pyrometer; 1. The fitness of this instrument, for the purposes of a measurer of heat, depends upon the property which clay has of contracting in high temperatures. This fact respecting clay has already been noticed, while enumerating the exceptions to the general law of the expansion of bodies by heat. Wedgewood's pyrometer consists of a number of pieces of clay of a determinate size, and an instrument for measuring their bulk with accuracy. The latter is formed of two brass rules twenty-four inches long, fastened upon a plate, half an inch apart at one end, and three-tenths of an inch at the other. The rules are divided into 240 equal parts, or tenths of an inch, called degrees. The clay pieces are small cylinders, first exposed to a red heat, and then made to fit between the brass rules, opposite the first degree of the scale, which therefore corresponds with a red heat, or 947° of Fahrenheit's thermometer.

how constructed.

How used. 2. The manner, in which a high temperature is ascertained by this instrument, is to expose one of the clay pieces to the heat, which it is intended to measure, until it has acquired the same temperature. It is then withdrawn from the fire, and when cool, slid between the brass rules; and the degree, which its bulk has diminished, is ascertained by the distance it is capable of passing up between the rules. Wherever it stops, the intensity of the heat is indicated by the corresponding divisions on the brass rules.

Not an exact measurer of heat. 3. It is to be regretted that the contraction, produced by the same degree of heat, in different pieces of clay is not precisely the same. This instrument, therefore, cannot be considered as an accurate measurer of heat. Notwithstanding, its invention has been attended with considerable practical utility, in ascertaining high temperatures, in operations in which great accuracy is not essential.

BOOK III.

OF THE GENERAL PROPERTIES OF MATTER, UPON WHICH CHEMICAL CHANGES DEPEND.

1. In the two books, just completed, of the science of chemistry properly so called, all the bodies, which come under the notice of the chemist, have been described, and a history of the chemical changes produced by their mutual action has been given. Those two books, therefore, may be considered as having been employed in recording the effects of chemical action: the causes of those effects, or the general principles upon which chemical changes occur, will form the subject of the present book.

Book III. The present book treats of the causes of chemical changes.

2. What takes place during any chemical change must be considered as a mere insulated fact; and reasoning upon such fact, the mind does not hesitate to believe, that, upon whatever properties impressed upon matter, the changes occurring in one chemical action depend, upon the very same properties all chemical changes must depend.

3. Chemical changes always take place at insensible distances; the causes of these changes, therefore, must operate at insensible distances also.

These changes take place at insensible distances, and depend upon attractions exerted between similar particles of matter; or between dissimilar particles. The former attraction is that of aggregation; the latter, chemical attraction.

4. Whatever the power may be, which holds together the particles of bodies which form masses, it is a force which operates at insensible distances. It is a force also, which varies in intensity, as is proved by the different degrees of counteracting force necessary to overcome it. This force has been called the attraction of aggregation.

5. Again: Whatever it may be which holds together dissimilar particles in a chemical compound, it is a force which acts at insensible distances also. That this force is different in intensity, when acting between different dissimilar particles, cannot be proved by any mechanical means, but this fact is demonstrated by what occurs in chemical decomposition; for here a force, which holds together dissimilar particles, is overcome by a force the same in kind; the overcoming force must, therefore, be greater in degree. This force, on account of its holding together dissimilar particles, is called chemical attraction, or, more usually, chemical affinity.

6. Thus it is perceived, that there may be fairly deduced, from the phenomena exhibited by matter, the existence of an attraction between its particles, acting at insensible distances, and varying in its intensity under different circum-

Book III. stances; and this attraction, so acting, may either be between particles the same in kind, or dissimilar particles.

7. The existence of an attraction, varying in intensity between dissimilar particles, is evinced in every chemical combination and decomposition. But the existence of such an attraction merely, without supposing it in some cases greater in intensity than the attraction of aggregation, would not be sufficient to explain chemical action; for supposing the attraction of aggregation to be always the stronger, there would be no force adequate to separate similar particles from each other. Hence, therefore, it may be said, that all chemical changes may be referred to the operation of an attraction, various in its intensity, which takes place at insensible distances between dissimilar particles of matter, and which, to be efficacious, must be stronger than the same kind of attraction, occurring between similar particles.

8. Having thus given an account of the general principles, upon which chemical changes occur, it will next be proper to consider the attractions concerned in them, namely the *attraction of aggregation*, and *chemical affinity*. This will be done in the two following chapters.

CHAPTER I.

OF THE ATTRACTION OF AGGREGATION.

(Syn. *Attraction of Cohesion—Corpuscular Attraction—Homogeneous Affinity.*)

Attraction of aggregation varies in intensity.

1. But a few words will be said under this head. There is no difficulty in understanding, that, by means of this attraction, matter is enabled to assume the form of masses. In solids, it has the greatest force; and in different individual solids, its intensity is very various. As a general rule, it is much the strongest in the metals, the tenacity of which depends upon the energy of this attraction. What is called strength in inanimate objects depends upon the degree of this attraction; and it is principally owing to the great tenacity or strength of the metals, that they are of such immense importance to mankind.

2. The attraction of aggregation between the particles of liquids, although much less than that between the particles of solids, nevertheless exists to a certain degree. With respect to water, it is proved in the formation of a drop of this liquid, in which every particle is urged towards the other by a certain degree of force, as is evinced by its spherical figure.

It is absent between the particles of gases.

3. Between the particles of gases, there is no attraction of aggregation. These fluids, as far as observation has yet

extended, are capable of indefinite expansion; so that the smallest portion of them may fill the largest imaginable space. Chap. I.

4. The attraction of aggregation, as has been already mentioned, is always opposed to the efficacy of chemical affinity. Whenever the particles of two dissimilar solids or liquids combine by chemical affinity, it is because this latter attraction is stronger than the attraction of aggregation between the individual particles of each body. This fact supplies the reason, why heat is so efficacious in facilitating chemical combination; for it lessens that power, which necessarily opposes chemical affinity. When a solid is converted into a liquid by heat, in so far it is rendered more capable of chemical combination. When a liquid is by the same means converted into an aeriform fluid, the attraction of aggregation, as an opposing force to chemical affinity, becomes entirely removed. It opposes the efficacy of chemical affinity.

CHAPTER II.

OF CHEMICAL AFFINITY.

(Sometimes called, *Heterogeneous Affinity*.)

1. Chemical affinity has already been explained to be that attraction, by which particles not of the same kind are held together. A particle of sulphate of soda is composed of a particle of sulphuric acid and a particle of soda, held together by chemical affinity; but the different particles of the salt itself are kept together by the attraction of aggregation. Chemical affinity explained.

2. The force of this peculiar attraction varies very much according to the bodies between which it is exerted; and it is upon this variableness in its force, that all the decompositions, which can be effected by the chemist, depend.

3. Chemists at an early period attempted to ascertain the laws of chemical affinity, by observing the phenomena of composition and decomposition.

4. The first step in this investigation was made in 1677 by Mayow, who demonstrated, that the previous notion, that the ingredients of any chemical compound are destroyed in their union, was not founded in truth. This chemist remarked, with some precision, the power, which certain substances have, of displacing others from their combinations. These observations were much further extended in 1718 by Geoffroy, senior, who ascertained a much larger number of decompositions, and attempted to prove, that bodies separate Its nature investigated by Mayow in 1677: and by Geoffroy, senior, in 1718.

Book III. each other from chemical combinations in an invariable order, which depended upon the comparative force of their attractions. This chemist was the first to construct tables of affinity.

Bergman published on the subject in 1775; and asserted that chemical affinity is an invariable force.

5. Nothing of importance was done, in investigating the laws of chemical affinity, from this period, until Bergman published his dissertation on *elective attractions* in 1775. According to this philosopher, chemical affinity is a certain invariable force; so that when a substance is presented to a compound, having a stronger affinity for one of its constituents than they have for each other, it necessarily combines with such constituent and separates the other. Bergman illustrated his opinions, and answered the objections of others with so much success, as to cause his doctrine to be universally admitted, and to be considered as some of the best demonstrated parts of the philosophy of chemistry. He constructed very copious tables of chemical affinity, in which the different chemical bodies were arranged in columns, in the order in which they separated each other, considered with reference to a given substance which was placed above them. The body, which separated all the rest, was placed at the head of the column, and the remainder in the order in which they separated each other.

The opinions of Bergman, combatted by Berthollet in 1803.

6. The opinions of Bergman on chemical affinity continued to receive the universal assent of chemists, until Berthollet published a dissertation on affinity in the third volume of the Memoirs of the Institute, and his Essay upon Chemical Statics, in 1803. According to this chemist, affinity is not an invariable force. It is, indeed, different in degree in different bodies; and the affinity of one body for any other is modified by the mass, in which it is presented for combination. A body, which has an affinity, for one ingredient of a compound, stronger than that by which such ingredient is held, does not necessarily separate the whole of such ingredient, but combines with a portion of it only; and the portion separated bears the same relation to that which remains still combined, as the respective affinities of the attracting body and the retaining body have to each other. Again; a body, reputed, by the old doctrine, to have a weaker affinity for one of the constituents of a compound than such constituents have for each other, may nevertheless, according to Berthollet, cause a partial decomposition, by bringing into operation the modifications occasioned by mass. For example, a large quantity of potash is capable of separating a portion of sulphuric acid from a small quantity of sulphate of barytes.

7. The doctrines of Berthollet, respecting affinity, are in

many respects very different from those advocated by Bergman. According to the last named chemist, when one affinity is greater than another, the weaker affinity has no influence in a result, and decomposition is necessarily complete: according to Berthollet, when a body has an attraction, for another body in combination, stronger than that by which such body is held, the body attracted does not become wholly separated, but is divided, between the attracting body and the body with which it was first united, in portions, bearing the same relation to each other, as the respective affinities of these bodies. According to Bergman, mass has no influence over decomposition: according to Berthollet, the power of attraction of the decomposing body is increased by the relative excess of its mass.

Doctrines of Bergman and Berthollet contrasted.

8. Although mass appears to be efficacious, it by no means identifies chemical affinity with gravitation; for it is not absolute but relative mass, which has an influence in modifying the force of chemical affinity.

9. The doctrines of chemical affinity, in their present unsettled state, seem to require for their explanation, that chemical combinations should be divided into those which take place in definite proportions, and those which do not occur in this way.

Doctrines on the subject of chemical affinity, very unsettled.

10. The reader has already been made acquainted with the leading features of the atomic theory in a preceding part of this work. All combinations, which tally with this theory, would appear to take place according to the principles of Bergman, mass being in nowise efficacious. This appears to be particularly the case in the mutual decomposition of salts, where there is a complete interchange of ingredients. But when bodies do not combine in definite proportions, then mass appears to be efficacious, by increasing the quantity, which one ingredient of a mixture may take up of some other ingredient without being saturated. For it would appear, that bodies have less attraction for others, with which they can combine in any proportion within certain limits, the nearer the quantities, with which they have already combined, approach such limits. For example, the increase of the mass of a solvent, while the body dissolved remains the same, unquestionably makes the limit of combination recede, and may thereby increase the affinity.

11. Since the new facts respecting chemical affinity have been made known, tables of affinity have become of comparatively little value. Tables, exhibiting the order in which bodies decompose each other, must be taken with certain exceptions. Thus, with respect to hydrogen and carbon, it is impossible to ascertain which has the greatest affinity for

Tables of chemical affinity do not give precise information.

Book III. oxygen; for, while charcoal decomposes water at a red heat, hydrogen in its turn is capable of decomposing carbonic acid at the same temperature. Several similar anomalies in decomposition obtain with regard to other bodies.

12. It is on these accounts, that the student cannot with any safety depend upon the information given by tables of chemical affinity. There is one general rule, however, which he may recollect with advantage. It is, that acids, either uncombined or as constituents of salts, almost invariably precipitate, from acid solutions, those bases, with which they form insoluble saline compounds. And this is equally true with regard to those bases, which form insoluble salts with particular acids. Hence the importance becomes evident of recollecting those salts which are insoluble.

PART II.

CHEMICAL EXAMINATION OF NATURE.

IT is proposed, in the second part of the present work, to make but a partial chemical examination of the different objects of nature. All material bodies are not equally interesting to the student of medicine. The mineral kingdom constitutes a very interesting study; but it is not a necessary part of medical chemistry. The vegetable kingdom furnishes a great number of important aliments and medicines: vegetables, therefore, will be examined so far, as to bring under consideration the nutritive or medicinal forms of the matter which compose them. With regard to animals, the view will be extended no farther than to give the chemistry of the different parts, which compose the human body.

PART II.

Subjects, embraced in the second part of the present work, are vegetables; the chemistry of the human body;

But in taking this partial chemical view of nature, the *atmosphere* which surrounds the globe, and *water*, which, in different states of purity, forms so important a part of it, must not be neglected to be noticed. These portions of nature are particularly interesting to the student of medicine, and should be carefully studied by him. Accordingly, the second part of this work will commence with an account of the atmosphere and water, forming the subject of a first book. Vegetable chemistry will then be considered in a second book, and human animal chemistry, in a third book.

and the atmosphere and waters of the globe.

BOOK I.

OF THE ATMOSPHERE AND WATER, GENERALLY.

PART II. Book I.

Nature of the atmosphere.

1. A very large proportion of the matter, which constitutes our globe, consists of the atmosphere, which floats round it on all sides, and the water, which covers so large a portion of its surface. The height of the atmosphere cannot be calculated; for the indefinite expansibility of air does not leave room for belief, that this fluid would ever refuse to expand in open space, however rare it might become. The weight of the atmosphere may be ascertained by observing the weight of a column of mercury, sustained by its pressure in a barometrical tube. The weight of a column of mercury, thus sustained, has been demonstrated to be equal to that of all the atmosphere, which presses upon a base equal to the base of such column. The height of the column sustained by the atmosphere is different at different times, and hence it is proved, that the weight of the atmosphere varies; but taking the mean height of the barometer to be thirty inches, and consequently the mean weight of the air to be indicated by the weight of such a column, then it is evident, that the weight of a hollow shell of mercury, enclosing the earth and thirty inches in thickness, would be the same as the weight of the whole atmosphere at a medium pressure. In this way, the atmosphere has been calculated to weigh more than 955 millions of millions of tons.

The water of the globe cannot be calculated with any degree of precision.

2. There is no method for ascertaining the quantity of water, of which the globe is formed, as there is no means of determining the depth of the ocean, which forms the great reservoir of this liquid. Upon the supposition, that the mean depth of the sea is not more than a quarter of a mile, and that three-quarters of the earth's surface is covered by it, Dr. Thomson calculates, that the solid contents of the ocean would be somewhat more than thirty-two millions of cubic miles.

3. What has been already said, respecting the atmosphere and water of the globe, may be considered as belonging to the department of mechanical philosophy rather than to chemistry. It now becomes proper to take up the consideration of these objects for investigation separately, in a chemical point of view; and this is done in the two following chapters.

CHAPTER I.

OF THE ATMOSPHERE.

1. It has already been stated in a foregoing part of this work, that the great bulk of the atmosphere consists of an air composed of oxygen and azote. This air has been called by chemists atmospheric air. But, besides this compound air, the atmosphere contains a variable quantity of water in a state of vapour, and a small proportion of carbonic acid. So that, excluding accidental bodies which may float in it, the atmosphere is made up of The atmosphere is made up of

1. Atmospheric air,
2. Vapour,
3. Carbonic acid.

1. Atmospheric air. 2. Vapour. 3. Carbonic acid.

2. In the common acceptation, however, of the term *atmospheric air*, the whole atmosphere is meant. The presence of vapour and carbonic acid, occurring in so small amount, does not alter perceptibly its properties; and when the mechanical properties of atmospheric air are investigated, it is sufficiently pure for the purpose of experiment, as it exists in the atmosphere.

3. Atmospheric air is an invisible elastic fluid. By reason of its elasticity, it is densest near the surface of the earth, and its density diminishes with its height. It has been ascertained by experiment, that the density decreases in a geometrical, as the height increases in an arithmetical progression. Its apparent visibility, deduced from the blue colour of the sky, has been ascertained to depend upon the presence of vapour. Saussure has found in his observations, that the sky has a deeper shade of blue, the higher the point is, from which it may be viewed. This circumstance, he ascribes to the diminishing quantity of vapours suspended in the higher regions of the air, affording a diminished reflection of light. Properties of atmospheric air.

4. By the common consent of chemists, atmospheric air is assumed as the standard, with which the specific gravities of all aeriform fluids are compared; and hence its specific gravity is taken at unity. Compared bulk for bulk with water, it is 828 times lighter than this liquid. One hundred cubic inches of it weigh 30.5 grains, troy. The weight of all gaseous fluids, compared with it as a standard.

5. According to the most accurate analyses, reduced to numbers which best accord with the atomic theory, atmospheric air is composed of Its composition given atomically;

Oxygen	8·00—one atom.
Azote	26·33—

From this statement it appears, that the proportion, in which oxygen and azote combine in the formation of atmos-

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pheric air, does not accord with any atomic supposition of combination. The quantity of azote, combined with one atom of oxygen, indicates somewhat less than two atoms. Atmospheric air is undoubtedly a chemical compound, although its ingredients may be united in a manner peculiar to the gases, when they combine without losing their gaseous form.

by bulk,

One hundred parts of atmospheric air are composed, by bulk of

Oxygen	21
Azote	79
	100

and by weight.

by weight of

Oxygen	23·299
Azote	76·701
	100·000

First step in the discovery of the constituents of atmospheric air, made by Priestley.

6. Having given the composition of atmospheric air, it is next proper to lay before the reader some account of the discovery of its compound nature. The first step in this object of research was made by Priestley, in his discovery of oxygen gas. This chemist supposed, that the gas now known by the name of azote was in fact nothing but oxygen gas saturated with phlogiston; and hence he believed, that common air was oxygen gas, combined with a variable quantity of this imaginary principle. About the same time that Priestley came to this conclusion respecting the nature of atmospheric air, Scheele was employed in making experiments with a view to determine its composition. This chemist found, that, upon exposing a given portion of air to the action of the liquid sulphurets, its bulk was diminished, and it was no longer capable of supporting flame. He, therefore, concluded, that the portion which gave the air the property of supporting flame had disappeared, and called what remained *foul air*. He ascertained also, that the air which had disappeared was the same with that, which is extricated from nitrate of potash (nitre), or peroxide of manganese by heat; since upon mixing this air with his *foul air* in certain proportions, he produced atmospheric air. To this latter air, he gave the name of *empyreal air*.

Scheele's researches upon atmospheric air;

and his conclusions.

7. Thus it appears, that Scheele discovered the actual constituents of atmospheric air. He, however, did not believe, that the effect of the liquid sulphurets was to absorb his empyreal air. According to his theory, this latter air disappeared in consequence of its combining with the phlogiston of the sulphuret; in which state of combination, he

supposed it to form caloric, and to pass through the vessel. So that Scheele, like Priestley, erred in the theory, which he adopted respecting the constituents of air.

Lavoisier first drew the proper conclusions from the experiments, which indicated the constituents of atmospheric air.

8. Lavoisier appears to have been the first chemist, who drew the proper conclusions from the experiments, which indicated the constituents of atmospheric air. He exposed mercury to its boiling heat, and found that it became converted into the peroxide (red oxide). Part of the air which had been confined over it had disappeared, and what remained was incapable of supporting flame. This chemist ascertained further, that the air which had disappeared had actually combined with the peroxide formed; for when this oxide was exposed to heat, it yielded an air, which, by mixture with the residual air just spoken of, reproduced the atmospheric air. Lavoisier also ascertained, that the liquid sulphurets actually absorbed one constituent of atmospheric air, the constituent afterwards known by the name of oxygen gas, and that the sulphur which they contained was acidified. Thus he disproved the theory of Scheele with respect to the disappearance of the oxygen gas.

The purity of atmospheric air, presumed at first to depend upon the quantity of oxygen it might contain.

9. As soon as the composition of atmospheric air was satisfactorily made out, upon comparing together the properties of its constituents, chemists very confidently concluded, that its purity must depend upon the quantity of oxygen which it might contain. Accordingly, they set about contriving a number of instruments, by which the proportion of oxygen, existing in any given portion of atmospheric air, might be measured. These instruments, from their supposed use in ascertaining the purity of air, were called eudiometers.

Principal eudiometers are those of Priestley, Scheele, Volta and Berthollet.

10. All the eudiometers invented agreed in being so many different plans, by which the oxygen contained in any given portion of air might be wholly abstracted; and the purity of the air experimented upon was supposed to be proportional to the smallness of the residuum. The principal ones are those of Priestley, of Scheele, of Volta, and of Berthollet. The eudiometer of Priestley depended, for the results which it gave, upon the property possessed by deutoxide of azote (nitrous gas), of absorbing oxygen gas from atmospheric air and being converted into nitrous acid. That of Scheele consisted of a portion of air, confined with an alkaline sulphuret, or a moistened mixture of iron filings and sulphur, in an inverted graduated glass tube, over water. These substances have the property of absorbing all the oxygen contained in any insulated portion of atmospheric air. Hence the quantity of the oxygen is indicated by the quantity of air which has disappeared, as measured by the ascent of the

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water in the tube. Volta's eudiometer consisted of a mixture, in proper proportions, of atmospheric air and hydrogen gas, which was fired by the electric spark. The hydrogen by its inflammation separates all the oxygen, the product being water; so that what remains is pure azote. The oxygen is indicated by the diminution in bulk of the airs employed. Berthollet's eudiometer indicated the proportional quantity of oxygen in atmospheric air by means of the slow combustion of phosphorus. This combustible was confined with a given portion of air over water. After the lapse of some time, the whole of the oxygen present became absorbed.

Atmospheric air always contains the same proportion of oxygen.

11. The result of the experiments made with eudiometers has been to show, that atmospheric air, from whatever situation it may be obtained, always contains the same proportions of oxygen and azote. Air has been examined from different parts of the world; it has been analyzed as it exists on the tops of the highest mountains, and in situations more than four thousand feet above the earth's surface, from which height it has been brought down by balloons; it has been subjected to experiments as it exists in places in the vicinity of marshes, and where putrid and noxious effluvia abound; and notwithstanding it has always been found to contain exactly the same proportions of oxygen and azote. Thus, then, have terminated the eudiometrical experiments, from which so much was expected in elucidation of the hidden causes of the unwholesomeness of air in particular situations, and during the prevalence of epidemic diseases. They have shown most clearly, that the causes, which render atmospheric air noxious, are not such as produce chemical changes upon it, but probably are of so hidden a nature as to be out of the reach of chemistry to discover.

Besides atmospheric air, the atmosphere contains water in a state of vapour.

12. Having finished the consideration of atmospheric air, of which very nearly the whole bulk of the atmosphere is composed; it is next proper to consider its other component parts, namely, water and carbonic acid.

13. It has been ascertained, that the atmosphere in its dryest state contains a quantity of water. Thus concentrated sulphuric acid abstracts moisture from it under all circumstances; and hence this acid by exposure to air becomes gradually more and more diluted, or in other words loses its strength. Some substances imbibe water from the atmosphere when it is loaded with moisture, and part with it again when it becomes comparatively dry. Such substances have been employed to measure the quantity of moisture, which may exist in the atmosphere at different times, by taking advantage of their property of expanding by absorp-

tion of moisture, and contracting by its abstraction. Instruments constructed by means of such substances are called *hygrometers*. Saussure's hygrometer is formed of a human hair, so arranged as to move an index. Deluc's hygrometer is the same in construction as Saussure's, but the hygrometric substance employed is a thin slip of whalebone. The hygrometer invented by Wilson consists of a rat's bladder, to which is fixed a tube, part of which, together with the bladder, is filled with mercury. The contractions or dilatations of the bladder produce a corresponding rising or falling of the mercury in the tube. The scales of hygrometers are formed by ascertaining two points, the extremes of moisture and dryness, and dividing the intervening space into one hundred equal parts, called degrees. The point of extreme dryness is obtained by exposing the hygrometer to air, made as dry as possible by salts which are known to have an avidity for moisture; and the point of extreme moisture, by exposing the instrument to air, in its most humid state.

Instruments which indicate the quantity of moisture in the atmosphere, called hygrometers.

14. It was originally supposed, that water existed in the atmosphere in a state of dissolution, and many philosophers have embraced this opinion. This supposition, however, appears to have been completely disproved by Dalton, who considers, that the water, existing in the atmosphere, is always in the form of an elastic vapour. The following very conclusive reasons have been adduced by this chemist in proof of this opinion.

Water is not dissolved in the atmosphere.

[1.] Water loses its liquid form faster when exposed to a rare air than to a dense air; and it disappears fastest of all in an exhausted receiver. Now this is just what ought to take place on the supposition, that water exists in the atmosphere in a state of vapour, but diametrically contrary to what ought to occur, if the atmosphere acted as a solvent merely.

[2.] When water disappears in air by what is called spontaneous evaporation, cold is generated. Now if the water which disappears is merely dissolved, there is no reason why cold should be produced; whereas, on the supposition that it exists in the air in a state of vapour, the production of cold would be a necessary consequence of its evaporation.

[3.] Mr. Dalton has proved that water, which is present in air, possesses the same degree of elasticity, as it does in a state of vapour, in a vacuum, at the same temperature. Therefore the conclusion is unavoidable, that it exists in the state of vapour in air.

15. Nothing has as yet been said respecting the quantity of water, in a state of vapour, in the atmosphere. This is

Quantity of water in the atmos-

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phere, various.

known to every one to be very variable. Saussure calculates, that a cubic foot of air, when fully saturated with moisture, contains about eight grains of water, or $\frac{1}{66}$th part of its weight. Dalton, from his experiments, concludes, that the medium quantity of vapour, held by the atmosphere in England, is $\frac{1}{70}$th of its bulk.

The third component part of the atmosphere is carbonic acid: it exists in all places, and at all heights. The quantity present differently stated by chemists.

16. The other ingredient in the atmosphere, carbonic acid, is always present, although in small amount. It has been detected in the atmosphere of mountains, and in air, which had been brought down from a very great height above the earth's surface by means of balloons. Its quantity, estimated by bulk, according to Humboldt, varies from one to half a per cent. Dalton calculates its quantity at $\frac{1}{1400}$th of the bulk of the atmosphere, that is, $\frac{1}{14}$th of one per cent.; but the method adopted by this chemist for ascertaining the point is not susceptible of much precision. Considering how great a quantity of this acid is formed during the respiration of animals and in combustion, it must be matter of surprise, that so small a portion of it exists in the atmosphere. It has been ascertained, that air, containing $\frac{1}{10}$th of its weight of carbonic acid, extinguishes flame and is noxious to animals. There is reason, however, to believe, that the vegetable kingdom prevents the occurrence of any over-proportion of carbonic acid in the atmosphere; as it has been completely ascertained, that plants decompose this acid during their vegetation.

CHAPTER II.

OF WATER.

1. Water having been noticed incidentally only under the head of hydrogen, it becomes necessary to give it a particular consideration; and this will be done in the present chapter.

Properties of pure water.

2. Water, rendered pure by distillation, is a transparent liquid, destitute of colour, taste, or smell. In its purest state in nature, it contains atmospheric air, carbonic acid, and carbonate of lime. It loses its gaseous constituents by boiling, and becomes flat and insipid. By the common consent of chemists, it is made the standard of comparison of the specific weight of all solid and liquid bodies. A cubic foot of water, at the temperature of 40°, at which point its density is greatest, weighs very nearly one thousand ounces, avoirdupois.

3. When cooled down to the temperature of 32°, water takes the crystallized form, and is called ice. When expo-

sed to a heat of 212°, it becomes an elastic fluid under the name of steam. Steam, at the temperature of 212° and under a medium pressure, is 1698 times lighter than an equal bulk of water. Its specific gravity is 0·623, compared with atmospheric air as 1. At high temperatures, its elasticity is exceedingly great. It is by its elasticity that steam acts, in causing the motion of that most useful machine the steam engine.

Its freezing point, 32°: boiling point, 212°.

4. Water, as it exists in nature, is distinguished by several names, according to its quality and the sources from which it is obtained. Rain water constitutes a very pure water; it contains, however, common air and carbonic acid gas, and some carbonate of lime. Snow water is very pure, and destitute of any air. The water of rivers is very variable in its purity, and as to the foreign bodies which it may contain; and this arises from the particular nature of its bed. In general, this water contains the usual gaseous constituents, together with a small quantity of carbonate of lime and chloride of sodium (common salt). Well water is generally a very impure kind of water. It is usually obtained from a very considerable depth in the earth, where water is almost always impregnated, by gradual filtration from the surface, with a number of salts. Well water is most frequently of that kind which is called *hard water*, so called from its curdling soap. Such water is unfit for washing clothes and other domestic purposes, and owes its property of decomposing soap to the presence generally of sulphate of lime (gypsum). The acid of this salt, when it meets with soap, combines with the alkaline base of the latter, while the lime forms an insoluble compound with its fixed oil.

Water is distinguished into several kinds.

5. By far the largest portion of the water of the globe contains, dissolved in it, a number of substances in pretty large amount, constituting what is called sea water. A great number of experiments have been made to ascertain the exact constituents of sea water. The amount of the substances dissolved in it has not been found to differ much in different latitudes; it varies from three to four per cent. 10,000 parts of sea water, obtained from the Frith of Forth, of the specific gravity of 1·029, was found by Dr. Murray to contain of

Sea water contains several substances.

Analysis of of sea water by Dr. Murray.

Chloride of sodium (common salt)	220·01
magnesium (muriate of magnesia)	42·08
calcium (muriate of lime)	7·84
Sulphate of soda (Glauber's salt)	33·16
	303·09

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This proportional quantity of constituents for sea water amounts to about 3 per cent. The chloride of sodium (common salt) amounts to 2½ per cent.

In analyses of sea water as usually made, the sulphates of lime and of magnesia are given. These salts are not among the constituents of sea water in the above analysis; and Dr. Murray has shown, that they do not exist in sea water, but are formed by double decompositions, which occur during the usual processes of analysis by evaporation and crystallization.

Effects of important chemical substances on water.

6. Some of the chemical relations of water have been given, in the account of almost every substance treated of in this work. Notwithstanding, it may be proper to recapitulate some of them in the present chapter. Water is not decomposed by any of the undecompounded supporters, or by phosphorus or sulphur; but charcoal, at a red heat, effects its decomposition, carbonic acid and bihydroguret of carbon being formed. It is decomposed rapidly by potassium and sodium, hydrogen being extricated, which inflames by the heat generated, and the combustibles themselves converted into potash and soda respectively. It is decomposed also, by iron, zinc, antimony, and tin, when assisted by heat; but is not acted upon by copper, silver, gold or platinum. It combines with the alkaline salifiable bases both in the solid and liquid form; but with the earthy bases, in the form of a hydrate only. It forms hydrates also with a number of salifiable bases of the third class, commonly called metallic oxides.

It is capable of being oxidized to various degrees.

7. Water is capable of combining with oxygen. This extraordinary discovery was made, towards the close of the last year, by Thenard, while pursuing his researches on the oxidizement of different substances, to which he was led by his previous discovery of the oxidized acids.

[1.] The first process, which Thenard pursued to oxidize water, was to pour, by degrees, barytes water upon oxysulphuric acid: sulphate of barytes was immediately formed, and the excess of oxygen of the acid became transferred to the water. By this method, water was obtained, containing six times its volume of oxygen. This chemist afterwards obtained water, containing forty-one times its volume, in the following manner: he placed 1200 parts of water, containing three and a half times its volume of oxygen, under the receiver of an air pump, with a capsule containing sulphuric acid placed above it. Upon exhausting the receiver, the oxidized water became congealed, and, after the lapse of some days, was reduced to 30 parts, which proved to contain all the oxygen, which existed originally in the 1200 parts.

[2.] Water, containing forty-one volumes of oxygen, was found to possess the following properties. It is an insipid, inodorous, colourless liquid, not decomposable by freezing, or in the vacuum of an air pump. It disengages its oxygen upon boiling. Its oxygen becomes disengaged also by the addition of metallic oxides, which are themselves reduced. Many metals produce the same effect. With respect to these decompositions, Thenard remarks, that they cannot be referred to the operation of ordinary affinities, but are most probably due to electricity. CHAP. II.

[3.] By employing a solution of peroxide of barium, and precipitating the barium by means of hydrochloric acid, Thenard subsequently succeeded in obtaining water, holding in combination as much as 120 times its volume of oxygen. Water, oxidized to this extent, by being concentrated under the receiver of an air pump along with sulphuric acid, was ultimately brought to contain 400 times its volume of oxygen.

Properties of peroxidized water.

[4.] Water, oxidized to this extent, when placed upon the skin, attacks the cuticle and turns it white, and, in a little time, causes violent pricking sensations. Its taste is a mixture of astringency and bitterness, producing a nauseous impression in the mouth. When a few drops of it are put into a tube, and a little oxide of silver added, a violent effervescence of oxygen takes place, and the tube becomes so hot, as not to admit of being held in the hand. After the action is over, the contents of the tube are pure water and metallic silver. If the same experiment be repeated with a somewhat larger quantity of the oxidized water, and with oxide of silver newly precipitated and yet moist, the extrication of oxygen is so sudden as to produce a sort of explosion.

[5.] Thenard has remarked, that one set of substances seem to increase the affinity of the oxygen for the water, while another set always tend to separate it. Belonging to the former are the acids; to the latter, the metals, their oxides, and sulphur and charcoal. These facts go to confirm the opinion, which this chemist holds, that the decompositions of oxidized water are due to the influence of electricity.*

Composition of water.

8. Water is composed, atomically, of

Oxygen	8—one atom.
Hydrogen	1—one atom.
	9

* Annales de Chimie et de Physique, tome ix. (1818) p. 314 et 441—tome x. (1819) p. 114.

Water the only oxide of hydrogen known.

Reflections on its nature.

9. Water is the only oxide of hydrogen known, and is a product in all cases of combustion. As a chemical body, it stands alone, having no tolerably exact analogy to any other substance. Considered as an oxide, it cannot be associated with any of the oxides of combustibles. Leaving out of the question its want of sensible properties, it has very few analogies, in its chemical relations, to these bodies, although similarly constituted with them. As an agent in chemistry, it is one of the most powerful employed; and although, by superficial observers, its want of sensible properties may be taken as an indication of inertness, yet this is by no means a fair conclusion. Sensible properties, as taste, smell, &c. form no part of chemistry. They may be enumerated to identify particular substances; but they have no connexion with chemical action. Water is as corrosive as pure potash or as nitric acid, if the human body be not taken as the standard of comparison. The chemical inertness of water, with regard to the human body and to living animals generally, was established by the great Author of nature for the wisest of purposes. Such a liquid as water was necessary for the use and preservation of living animals. To answer the ends for which it was intended, it must not act upon the matter of which living bodies are formed, and it must be free from taste, smell or colour; but none of these qualities impressed upon it, make it less active in its general relations as a chemical agent.

Composition of water discovered in consequence of the researches made to ascertain the product of the combustion of hydrogen.

10. The composition of water was discovered in consequence of the researches made by chemists into the phenomena, attendant upon the combustion of hydrogen gas. At the time these researches were made, water was considered to be an elementary substance, and no experiments had been instituted under the influence of a contrary belief. Scheele was the first chemist, who made experiments with a view to discover the product of the combustion of hydrogen. This chemist concluded, that the gas, during this process, combined with oxygen and formed caloric, supposing that hydrogen was identical with phlogiston. In 1776 Macquer set fire to a quantity of hydrogen in a bottle, and held a saucer over the flame, in order to ascertain the product. The saucer was moistened with a liquid, which proved to be pure water. It would seem, however, that no particular conclusion was drawn from this experiment. The succeeding year Bucquet and Lavoisier exploded oxygen and hydrogen gases with a view to discover the product. Bucquet supposed it would be carbonic acid, while Lavoisier was inclined to believe that it would be sulphuric or sulphurous acid. They did not discover what the product was, but ascertained that Buc-

quet's suspicion was ill founded. In the beginning of the year 1781, Dr. Priestley fired a mixture of oxygen and hydrogen gases in a glass vessel. The inside of the vessel became moist, and covered with a sooty appearance. Dr. Priestley, however, did not come to the proper conclusion from his experiment. He afterwards ascertained, that the sooty matter which appeared was derived from the mercury which had been used in the filling of the vessel.

11. In the summer of 1781, Cavendish fired a large quantity of hydrogen gas, mixed with atmospheric air, and obtained a portion of pure water. He exploded the same gas mixed with oxygen gas, and the product was the same. From these experiments, Cavendish concluded, that the product of the combustion of hydrogen is water; and, as hydrogen combines with oxygen during combustion, that water must be a compound of oxygen and hydrogen. Thus Cavendish, by succeeding in ascertaining the product of the combustion of hydrogen, made the memorable discovery at once of the compound nature, and of the component parts of water. Two years afterwards, the discovery was amply confirmed by Lavoisier and La Place, who repeated the experiments of Cavendish upon a very large scale; and since that time, the chemical nature of water has been indicated by so many experiments, conducted as well by the analytic method as synthetically, as to put the truth of the discovery beyond the reach of controversy.

Cavendish, the real discoverer of the compound nature of water.

BOOK II.

VEGETABLE CHEMISTRY.

Part II. Book II.

Vegetable chemistry treated of under the two heads of proximate constituents, and ultimate constituents.

Vegetable Chemistry will be considered in two chapters. The first chapter will describe the peculiar compound substances of which vegetables are formed, under the name of the proximate constituents of vegetables. The second chapter will give a view of all the undecompounded substances yet discovered in plants; and these will be called the ultimate constituents of vegetables.

CHAPTER I.

OF THE PROXIMATE CONSTITUENTS OF VEGETABLES.

Proximate constituents of vegetables, divided into five sets.

The proximate constituents of vegetables will be divided into five different sets or groups, in conformity with the arrangement of Dr. Thomson, which is adopted in the present chapter with but slight modifications. These sets are characterized as follows:

First set.—Substances soluble in cold water. These are

1 Acids.	6. Mucus.	10. Bitter Principles.
2. Tannin.	7. Jelly.	11. Nicotin.
3. Sugar.	8. Ulmin.	12. Extractive.
4. Sarcocoll.	9. Colouring Principles.	13. Emetin.
5. Gum.		

Second set.—Substances insoluble in cold water, but partially soluble in hot. These are

1. Morphia.	5. Inulin.	8. Gluten.
2. Strychnin.	6. Starch.	9. Pollenin.
3. Asparagin.	7. Indigo.	10. Fibrin.
4. Cerasin.		

Third set.—Substances which melt when heated, if not already liquid, and burn like oils. These are

1. Oils.	4. Bird-lime.	7. Balsams.
2. Wax.	5. Resins.	8. Gum-resins.
3. Camphor.	6. Guaiacum.	9. Caoutchouc.

Fourth set.—Substances which are insoluble in water, alcohol, or ether, and which have a fibrous or woody texture. These are

1. Cotton.	3. Medullin.	5. Fungin.
2. Suber.	4. Lignin.	

Fifth set.—Substances which belong rather to the mineral than the vegetable kingdom, and are found as ingredients of plants. These are either

1. Chlorides.	2. Acids.	3. Salifiable Bases.

FIRST SET.

SUBSTANCES SOLUBLE IN COLD WATER.

SECTION I.

OF VEGETABLE ACIDS.

1. THE following acids have been found in plants. Acids found in plants enumerated.

1. Acetic acid.	6. Boletic acid.	10. Hydrocyanic acid.
2. Oxalic acid.	7. Malic acid.	11. Hydriodic acid.
3. Tartaric acid.	8. Sorbic acid.	12. Kinic acid.
4. Citric acid.	9. Benzoic acid.	13. Gallic acid.
5. Moroxylic acid.		

2. The acetic acid has been found in the sambucus nigra (common elder), and several other plants. The oxalic acid, combined with potash, is found in the oxalis acetosella or wood-sorrel, and several other plants; combined with lime, it exists in the root of rhubarb, and in a variety of vegetable roots and barks. Tartaric acid has been found in a number of vegetable substances, but most abundantly in the juice of grapes. Citric acid exists most abundantly in the juice of oranges and lemons: it is also found in the juice of the cranberry and red whortleberry. Moroxylic acid has hitherto been found only in the bark of the morus alba, or white mulberry. The boletus pseudo-igniarius is the only plant in which the boletic acid has hitherto been found.

3. Malic acid has been found very abundantly in apples. It has also been detected in the fruit of the barberry and of the elder, and in the plum and the sloe. It has been found, associated with citric acid in nearly equal quantity, in the gooseberry, in currants, in the cherry, the strawberry and the raspberry. It has been detected in a number of other plants combined either with lime or potash. Plants which furnish malic acid.

4. Sorbic acid was discovered in the juice of the pyrus aucuparia or mountain ash, together with the malic acid. It is found, associated with the same acid, in apples, plums, barberries and sloes.

5. Benzoic acid has been found in a few vegetable substances only, such as benzoin, balsam of Tolu, storax, &c.

6. From the time that the hydrocyanic (prussic) acid was obtained in a separate state, its similarity in smell to bitter almonds and peach blossoms did not fail to be observed. It has been ascertained, that the water distilled from these almonds contains hydrocyanic acid, and is capable, when mixed with potash, of precipitating Prussian blue from solutions of iron. The distilled water of the leaves of the prunus lauro-cerasus (cherry tree laurel) contains this acid, and Hydrocyanic acid, found in bitter almonds, and several other vegetable substances.

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owes its narcotic and deleterious properties to its presence. It has also been found in the flowers of the sloe, and in the leaves of the bay-leaved willow. There can be very little doubt that it exists in all the bitter kernels.

Hydriodic acid exists in fuci.

7. After hydrocyanic acid is the best place to mention hydriodic acid, in the enumeration of the acids of vegetable origin. Iodine having been discovered in kelp, the product of the incineration of marine vegetables, chemists were led to examine the marine vegetables themselves. Accordingly some of the fuci were subjected to analysis, during the years 1814 and 1815, by H. Davy, Gaultier de Claubry, and John. Davy discovered traces of iodine in them; but Gaultier de Claubry has subjected several of them to an elaborate analysis, by which it appears, that iodine exists in them in the state of hydriodic acid, combined with potash.

8. Kinic acid has heretofore been found in the cinchona officinalis or peruvian bark only, combined with lime.

9. Gallic acid exists in a great number of plants, chiefly in their barks. As far as observation has yet extended, it occurs most abundantly in different species of oak and in sumach.

SECTION II.

OF TANNIN.

Tannin exists in nut-galls.

1. Tannin is a peculiar vegetable substance, which exists very abundantly in nut-galls. The soluble portion of these vegetable productions, which amounts to somewhat less than two-fifths of their weight, is found to consist of two-thirds tannin, and the remaining third, of gallic acid, mucilage, extractive and lime. Many methods have been proposed to obtain the tannin perfectly pure from the solution, but none of them appear to answer the purpose completely. It may be obtained tolerably pure by mixing lime water with the solution, and treating the precipitate thus formed with diluted nitric acid. Upon filtration a substance is left behind, which is tannin, contaminated however with a portion of extractive.

Account of its discovery.

2. Dr. Lewis, while pursuing some experiments instituted to ascertain the best method of making ink, observed some of the properties of tannin, without being able to obtain it in a separate state. Deyeux was, perhaps, the first chemist, who made out the peculiar nature of tannin. Seguin ascertained, that it was the substance which combined with leather in the process of tanning. Hence it was called tannin or the tanning principle by the French chemists.

Properties.

3. Tannin, in the purest state in which it can be obtained, is a brittle substance, possessing a brown colour, and breaking with a resinous fracture. Its taste is bitter and very astringent. It dissolves readily in both hot and cold water, and forms a solution, which does not undergo spontaneous decomposition. It is insoluble in pure alcohol; but alcohol, containing $\frac{1}{10}$th of its weight of water, is capable of effecting its solution. Nitric acid communicates oxygen to it, and converts it into a yellowish-brown matter, similar in properties to extractive. With the metals, it does not appear to combine; but with most of their oxides, it forms insoluble compounds. This latter property makes the infusion of nutgalls very useful in precipitating metallic solutions.

Forms an insoluble compound with gelatin.

4. One of the most important properties of tannin is that of forming an insoluble compound with gelatin (glue). Hence these two substances are reciprocally the tests of each other. It combines with all the alkaline, and nearly all the earthy bases, and is thereby deprived of its property of precipitating gelatin. It combines also with most of the acids, forming with them compounds more or less soluble. Nitric and sulphuric acids, however, decompose it by their action.

5. According to Berzelius, tannin is composed of

Hydrogen	4·186
Carbon	51·160
Oxygen	44·654
	100·000

Artificial tannin obtained by the action of nitric acid on charcoal.

6. A substance, very similar to the tannin found ready formed in certain vegetables, may be obtained by the action of diluted nitric acid on charcoal. It is called artificial tannin. Science is indebted for this discovery to Hatchett. It is formed by mixing together 100 grains of charcoal, and 500 grains of nitric acid of the specific gravity of 1·40, diluted with twice its weight of water. The mixture is then exposed to heat, which produces an effervescence, occasioned by the escape of deutoxide of azote (nitrous gas). After two days digestion, more nitric acid is added, and the heat continued, until the solution is complete. The solution is then evaporated to dryness, whereby a brown-coloured mass is obtained, which is artificial tannin.

Properties of artificial tannin.

7. Artificial tannin agrees very nearly in properties with natural tannin. It differs, however, from the latter, in being soluble without alteration in nitric acid. In composition, it differs also by containing azote in addition to the ingredients of natural tannin.

8. Hatchett has found, that every species of charcoal is susceptible of conversion into artificial tannin by the action

of nitric acid. He has ascertained, that it may be formed also by digesting nitric acid upon several substances, which contain a large proportion of carbon; as for instance, indigo and several of the resins. When formed from these substances, however, the tannin is somewhat different from that formed from charcoal. The same chemist has found, that sulphuric acid, digested upon the resins or camphor, converts these bodies into a substance analogous to tannin.

Tannin exists ready formed in many plants.

9. Tannin exists ready formed in many vegetable substances besides nut-galls, but appears to have some variety in its properties, according to the vegetable from which it is obtained. It is considered, that the oak furnishes the same variety of tannin, which is obtained from nut-galls. More than half the weight of catechu, or the Japan earth as it is improperly called, is composed of a variety of tannin. Another variety of this substance constitutes a very large proportion of the kino of the shops. In fact, tannin may be considered the peculiar principle, which gives astringency to vegetable substances. It is to the property of tannin of forming an insoluble compound with gelatin, that its usefulness in the art of tanning is to be attributed; since the hide is converted into leather by its gelatin uniting to the tanning principle.

SECTION III.

OF SUGAR.

Sugar is chiefly obtained from the sugar cane.

1. SUGAR is a peculiar vegetable substance, chiefly obtained from the sugar cane, by inspissating its expressed juice by boiling. By this first preparation, it forms a brown granular substance, constituting an impure sugar. It is purified by being dissolved in water, mixture with lime, and treatment with bullock's blood. It is then boiled to a proper consistence, and cleared of its impurities, as they rise to the top, by scumming. It is afterwards poured into unglazed conical earthen pots, whose apices are perforated to allow impurities to separate. The base of the cone is covered with moist clay, which allows a small portion of water gradually to filter through the sugar, with the effect of removing some further impurities. It is now in the state of loaf sugar.

Its properties.

2. Sugar, in the pure state, is a white, brittle substance of some hardness, having a very strong sweet taste, but no smell. It is not altered by exposure to air. Water, at the temperature of 48°, dissolves its own weight of it, and boiling water, any quantity. In the form of a saturated so-

lution, it is called syrup. It is also soluble in alcohol, but less so than in water. Its specific gravity is between 1·4 and 1·6. CHAP. I.

3. Sugar appears to be capable of combining with both acids and salifiable bases. Sulphuric and hydrochloric acids convert the greater part of it into charcoal. Nitric acid changes it into oxalic and malic acids.

4. When exposed to heat, sugar melts, becomes blackish-brown, emits air-bubbles and exhales a peculiar smell. At a red heat, it bursts into flames, which are white with blue edges.

Composition.

5. By being burnt with chlorate of potash, sugar was found by Gay-Lussac and Thenard to be composed of

Oxygen	50·63
Carbon	42·47
Hydrogen	6·90
	100·00

Sugar is of different kinds.

6. Besides the common sugar which is obtained from the sugar-cane, and the sugar extracted from the sap of the sugar-maple and from the beet, which does not appear to differ from common sugar, there are several other species of sugar, each having distinctive properties.

Liquid sugar exists in several vegetable substances.

7. There is a sugar, which differs from common sugar in being always in the liquid form. It exists in the sugar cane, and forms a considerable part of molasses. It exists also in a number of fruits, such as grapes, peaches, apples, &c. and has been extracted from the stalks of Indian corn. Besides this sugar, the sugar of figs, of grapes, and that which exudes from the fraxinus ornus, a species of ash, are all peculiar sugars. The latter, under the name of manna, constitutes a valuable laxative; and differs from common sugar, in being much more abundantly soluble in alcohol, in yielding saclactic as well as oxalic acid by the action of nitric acid, and in not being fermentable.

Starch may be converted into sugar.

8. Starch may be converted into sugar, possessing the same properties as the sugar of grapes, by mixture with four times its weight of water, and $\frac{1}{100}$th part of its weight of sulphuric acid, and exposure to a boiling heat for 36 hours, supplying water as fast as it evaporates. The acid is then saturated with lime, and the insoluble sulphate of lime, which becomes formed, separated. The remaining liquid, after concentration by heat, is found to contain a peculiar sugar. The manner, in which the conversion is effected by this treatment, is not understood.

9. Sugar is undoubtedly one of the most nutritious substances known. It constitutes a very important part of the

plants. It may be obtained, in its purest form, from flax-seed. It may be extracted also, with some differences in properties, from quince seeds and from the root of the hyacinth. It exists in considerable quantities in mallows, in the leaves of the althæa, in many of the fuci, but in a still greater number of the lichens.

2. Mucus is distinguished from gum, in being precipitated copiously from its solution in water by acetate of lead; in being thrown down by alcohol in white flakes, which do not render the liquid opaque, as happens under similar circumstances with gum; and in remaining unaltered upon the addition of silicated potash.

SECTION VII.

OF JELLY.

Jelly may be obtained from several fruits.

1. Jelly appears to be a peculiar vegetable substance. It may be obtained from ripe blackberries, currants, oranges, lemons, gooseberries, and similar fruits, by allowing their expressed juice to gelatinize, and afterwards to drain upon a fine sieve. In this way the acid parts separate and pass through the sieve, while the jelly in a tolerably pure state remains behind. It is then washed with a little cold water, to separate any adhering acid.

Its properties.

2. Jelly, upon drying, contracts considerably in bulk, and becomes a hard transparent brittle mass, very analogous in appearance to gum. Before drying, it is nearly colourless, if deprived of the colouring matter of the fruit, from which it is obtained. It has a pleasant taste and a tremulous consistency. It is scarcely soluble in cold water, but dissolves readily in hot water, from which it gelatinizes upon cooling.

SECTION VIII.

OF ULMIN.

Ulmin, an exudation from the elm.

1. Ulmin is a peculiar substance, discovered in 1804 by Klaproth, combined with carbonate of potash, in a spontaneous exudation from the elm. It has since been found, that it forms a constituent in the bark of almost all trees. It has a dark brown colour, and is destitute of taste or smell. It is but sparingly soluble in water or alcohol, but readily so in a weak solution of carbonate of potash. It is obtained from the barks, which furnish it, by digestion in a hot solution of this salt, after having been digested first in alcohol and then

in water. Its aqueous solution is precipitated in brown flocks by pernitrate of mercury and acetate of lead; and the alcoholic solution, by the sulphates of iron and of copper of the same colour.

SECTION IX.

OF COLOURING PRINCIPLES.

Two substances will be noticed under this head; namely, polychroite and hematin.

Colouring principles are, polychroite, the colouring principle of saffron; and

I. Polychroite is the name given by Bouillon Lagrange, and Vogel to the colouring matter of the crocus sativus or saffron, on account of the variety of colours which it is capable of assuming. It is obtained by evaporating the aqueous infusion of the plant to the consistence of honey; and in that state, digesting it in alcohol, filtering the alcoholic solution, and evaporating to dryness. The dry mass is pure polychroite. It has an intensely yellow colour. It is very soluble both in alcohol and water, but scarcely so in sulphuric ether. When exposed to the air, it absorbs moisture and is converted into a viscid liquid.

hematin, the colouring principle of logwood.

II. Hematin is the name given by Chevreul to the substance, first recognised by him to be of a peculiar nature, which constitutes the colouring matter of the hæmatoxylon campechianum, or logwood, so well known as a dye stuff. It is obtained in the following manner: Digest logwood in powder for several hours in water, at the temperature of 125°. Filter the solution thus obtained, and evaporate to dryness. Digest the dry mass for a day in alcohol, filter the alcoholic solution formed, concentrate it by heat, and then add a little water, and afterwards evaporate a little further. Crystals will form in the liquid of hematin, which, after being washed with alcohol and dried, may be considered as pure. They are small and brilliant, possessing a reddish-white colour, and a slightly astringent, bitter, acrid taste. Boiling water dissolves them with facility, and becomes of an orange-red colour.

SECTION X.

OF BITTER PRINCIPLES.

Bitter principles exist in a number of plants.

Many vegetables of a bitter taste yield, by peculiar treatment, a substance, to which their bitter qualities are owing, and hence called their bitter principle. The bitter principle,

however, differs according to the plants from which it is obtained. The following are its principal varieties.

Quassin, the bitter principle of quassia.

I. QUASSIN.—This is the name given to the substance, obtained by evaporating water to dryness, which has been digested upon the wood called quassia. It is a brownish-yellow substance of an intensely bitter taste. It is very soluble in water and alcohol. When heated, it softens, swells and blackens, and then burns away without much flame, leaving a small quantity of ashes.

Vauquelin has ascertained, that the fruit of the colocynth (cucumis colocynthis) and the root of briony (brionia alba), two vegetable substances possessing narcotic properties, contain a bitter principle, which, as far as observation has gone, possesses exactly the same properties as the bitter principle of quassia.

Picrotoxin, obtained from the cocculus indicus.

II. PICROTOXIN.*—Boullay designates by this name a peculiar substance, which he obtained from the cocculus indicus, the fruit of the *menispermum cocculus*, and which possesses a bitter taste, and intoxicating and poisoning qualities. It is separated from the berries by treating them alternately with water and alcohol. It is in the form of crystals of a white colour. It possesses the property of neutralizing acids, and constitutes one of the newly discovered salifiable bases of vegetable origin.

Scillitin, the bitter principle of squill.

III. SCILLITIN.—This is the name given by Vogel to a peculiar substance, which may be extracted from the bulb of the scilla maritima, or squill. It comes properly under the denomination of a bitter principle. It is a white and transparent substance, which breaks with a resinous fracture. By exposure to air, it becomes a viscid mass. Its taste is intensely bitter, leaving some impression of sweetness on the tongue. It forms with water a mucilaginous solution. It is soluble in alcohol.

Caffein, the bitter principle of coffee.

IV. CAFFEIN.—This substance may be obtained from unburnt coffee by the following process. Treat the liquid, formed by digesting the grains in water, being first filtered, with hydrochlorate of tin. Wash the precipitate which will thereby be formed, and, having mixed it with water, pass a current of hydrosulphuric acid (sulphuretted hydrogen) through it. The tin will thereby be precipitated, and the remaining liquid will be found to hold in solution the peculiar substance caffein. This substance is semitransparent like horn, and has a yellow colour. It is soluble both in water and alcohol. Its solution in water is semitransparent, and

* From πικρος, bitter, and τοξικον, poison.

has a pleasant bitter taste. When it is treated with solutions of potash or soda, its colour is changed to garnet-red. Solutions of iron change it to a fine green. This is the most characteristic property of caffein.

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Dr. Thomson has reason to believe, that the bitter principle of the following plants is the same with that of coffee; namely, absynthium vulgare (worm-wood), juniperus sabinus (savine), ruta graveolens (rue), anthemis nobilis (chamomile), achillea millefolium (milfoil.)

Daphnin.

V. Daphnin.—This is the bitter principle of the daphne alpina. It is a hard crystallizable substance, of a greyish colour and bitter taste.

Artificial bitter principle, obtained from silk and other substances by the action of nitric acid.

VI. Artificial bitter principle.—The substance, to which this name is applied, is formed by the action of nitric acid upon various vegetable and animal substances. It was originally obtained from silk by the action of nitric acid. It has also been formed, by the action of the same acid, from the white willow and indigo. It is a crystallizable substance, of a deep yellow colour and intensely bitter taste. It is capable of dyeing silk, woollen cloth, and cotton of a durable yellow colour. It has the property of an acid, in so far as to form compounds analogous to salts by combining with the salifiable bases.

SECTION XI.

OF NICOTIN.

Nicotin, the characteristic principle of tobacco.

1. This substance was discovered by Vauquelin as the principle to which tobacco owes its peculiar properties. It is obtained by dissolving the inspissated juice of tobacco in alcohol, which takes up the nicotin as well as uncombined malic and acetic acids. The alcoholic solution is evaporated to dryness, and the dry mass dissolved in water. The uncombined acids are then saturated with potash, and the water distilled off to dryness. This water, although colourless, is a solution of nicotin. From this solution, the nicotin may be obtained by cautiously driving off the water by evaporation. Nicotin is a colourless substance, having the peculiar smell and taste of tobacco. It possesses poisonous properties. It produces violent sneezing. Its solution either in alcohol or water has the same taste and smell. It is volatile, and has some analogy to the volatile oils.

SECTION XII.

OF EXTRACTIVE.

The term extractive used in different senses.

1. The term extract or extractive has been used in many different senses. In its original acceptation, it meant those parts of plants, which are soluble in water, and may be obtained from this liquid by evaporation. In the present section, the term extractive is applied to a peculiar vegetable substance, which may be obtained from a great number of plants, and which possesses the following general properties. It is soluble in water, with which it forms a solution always coloured. Absolute alcohol or ether does not dissolve it, but it is soluble in common alcohol. Its taste is always strong, but different as obtained from different plants. By repeated solutions and evaporations, it becomes deeper coloured, and at last insoluble. Its solution, when exposed to the air, is liable to putrefaction. When mixed with sulphate or hydrochlorate of alumina, a precipitate falls, consisting of alumina and extractive combined. It is precipitated from its solutions by hydrochloric or sulphuric acid. It unites with the alkaline bases, as well as with most of the salifiable bases of the third class, usually called metallic oxides, forming insoluble compounds.

Extractive, different as obtained from different vegetables.

2. Extractive is different in its properties, according to the vegetable substance from which it may be obtained. It exists in the sap of almost all the trees which have been examined. It is thrown down from this vegetable liquid by means of chlorine, or by evaporation at a sand heat. It is a constituent also in all barks, as far as they have been the subject of experiment. It almost always accompanies tannin.

3. Extractive is present in catechu. It may be obtained from this astringent substance by repeated washings, until the water which comes off gives no indication of the presence of tannin upon the addition of gelatin. What remains will consist of extractive.

4. Senna dissolves in twice its weight of cold water, and forms an infusion, which contains, besides a considerable proportion of carbonate of lime, sulphate of potash, carbonate of magnesia and a little silica, a certain quantity of extractive. This may be made evident by means of hydrochloric acid or chlorine, either of which throws down the extractive somewhat altered in its properties. The extractive of senna, when placed upon burning coals, emits a thick smoke and exhales an aromatic smell, the residuum being a spongy charcoal.

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5. Peruvian bark was found by Fourcroy to contain a peculiar extractive. It is separated, by treating the watery extract of the bark with alcohol. The alcoholic solution thus obtained, by evaporation, affords the extractive. When dry, it is a black and brittle substance, which breaks with a polished fracture. Its taste is bitter. It is insoluble in cold water, but dissolves in hot water and in alcohol.

SECTION XIII.

OF EMETIN.

Emetin, the peculiar principle of ipecacuanha.

1. EMETIN is the name given to the peculiar substance, discovered in ipecacuanha by Majendie and Pelletier, to which this vegetable owes its emetic property.

2. It is obtained in the following manner. An alcoholic solution of ipecacuanha which had previously been digested in sulphuric ether, is evaporated to dryness; and the dry mass obtained, dissolved in water, and treated with a solution of acetate of lead. A precipitate is thereby formed, composed of emetin and oxide of lead. This precipitate, being washed and diffused in water, is subjected to the action of hydrosulphuric acid gas (sulphuretted hydrogen). This acid gas throws down the lead, and the disengaged emetin dissolves in the water. It is afterwards obtained from its aqueous solution by evaporation to dryness.

Its properties.

3. Emetin is a brownish-red uncrystallizable substance, in the form of transparent scales, destitute of smell, and having a taste, bitter and somewhat acrid, but not in the least nauseous. It is soluble both in water and in alcohol. It is not affected by any heat below the boiling point; and above that temperature, it does not melt, but swells, blackens, and is decomposed into water, carbonic acid, a little oil, and acetic acid.

4. It is not acted on by sulphuric acid in a diluted state, but when concentrated, it is charred and destroyed by its action. Nitric acid forms with it a red-coloured solution, gradually becoming yellow, and depositing crystals of oxalic acid. Hydrochloric and phosphoric acids dissolve it without alteration. Acetic acid is one of its best solvents. Acetate of lead precipitates it from solutions in abundance.

Its action upon the animal economy.

5. When given to the amount of half a grain, it proves violently emetic. Its operation is followed by sleep. In doses of twelve grains, or even much smaller ones, it proves fatal. Upon dissection after death produced by it, it was found that the lungs and intestinal canal were inflamed.

SECOND SET.

SUBSTANCES INSOLUBLE IN COLD WATER, BUT PARTIALLY SOLUBLE IN HOT.

SECTION I.

OF MORPHIA.

Morphia, the narcotic principle of opium.

1. Sertürner gives the name of morphia to a peculiar substance, which he discovered in 1817 in opium, and to which this vegetable medicine owes its narcotic properties. Precisely the same substance has been ascertained by Vauquelin to exist in the opium from the garden poppy.

2. This substance exists in opium combined with a peculiar acid, which Sertürner calls meconic* acid.† It is extracted by the following process. Rub together eight ounces of pulverized opium with two or three ounces of strong acetic acid and a little water, until the whole has assumed the consistency of a soft pap. Pour upon the mixture, thus formed, two or three pounds of water, and strain the whole through a cloth. A coloured liquid passes through, which contains acetic acid and meconate of morphia, a little morphia combined with extractive, and neutralized free extractive. Upon the addition of caustic ammonia, morphia, contaminated with extractive, is thrown down in abundance. To separate the extractive, digest the impure morphia in a very small quantity of alcohol. This liquid takes up the extractive and leaves the morphia behind.

Its properties.

3. Morphia is a colourless crystallizable substance, sparingly soluble in boiling water, but forming solutions readily with alcohol or ether which have a bitter taste. It combines with many of the acids, forming neutral compounds, and appears, in some respects, to bear considerable analogy to the alkaline salifiable bases. When exposed to a gentle heat, it melts and assumes somewhat of the appearance of melted sulphur. It burns easily in the open air; but when heated in close vessels, it is converted into a solid resinous black mass, having a peculiar smell. It has not been analyzed, but Sertürner considers it to be a compound of oxygen, carbon and hydrogen.

Its action on the human system.

4. Morphia is found to exert a powerful action upon the animal system. When given in the dose of half a grain,

* From μηκων, the poppy.

† In a late number of the Annales de Chimie (Nov. 1818), Vauquelin attributes the discovery of morphia and meconic acid to Seguin. He certainly proves that Seguin insulated and characterized both these substances, although he did not appropriate to them peculiar names.

dissolved in spirits, to a young person, it produced flushing of the face, and an increase of muscular power. The same dose, repeated in half an hour, occasioned a dull pain in the head, giddiness, stupor and nausea. A third dose of half a grain being given, all the effects of the substance were so much increased, as to create alarm for the safety of the subject of the experiment. CHAP. I.

SECTION II.

OF STRYCHNIN.*

Strychnin, the deleterious principle of the nux vomica and St. Ignatius's bean.

1. PELLETIER and Caventou have succeeded in obtaining the poisonous principle of the nux vomica and St. Ignatius's bean in a separate state, which proves to be the same in both. The plants which furnish these substances belong to the genus strychnos. The wood of another species of this genus (s. colubrina) has yielded, to these chemists, the same peculiar principle. It is in consideration of these facts, that Pelletier and Caventou have named the peculiar principle *strychnin*.

Its properties.

2. Strychnin is a white and granular substance, scarcely soluble in water. Notwithstanding its sparing solubility, it possesses a very intensely bitter taste. The impression, which it leaves upon the mouth, has been compared to that occasioned by the metallic salts. It is entirely destitute of smell. It restores the colour of vegetable blues, previously reddened by acids. It suffers no alteration in the air. When exposed to a heat gradually increased, it is decomposed at a lower temperature than is sufficient to destroy the generality of vegetable substances, and charcoal is developed. The products of its decomposition by heat are an empyreumatic oil, some acetic acid, carbonic acid, bihydroguret of carbon (carburetted hydrogen) and a bulky charcoal. It is consequently composed of oxygen, hydrogen, and carbon.

3. Strychnin possesses the properties of a salifiable base, inasmuch as it forms with acids neutral compounds, which are transparent, soluble, and crystallizable. A number of salts have already been formed from it, and their properties noticed by Pelletier and Caventou. It forms a peculiar salt with nitric acid, when diluted; but is changed to a red colour and altered in its properties by the action of this

* It has already been mentioned, that Dr. Thomson's classification of vegetable proximate constituents is adopted in this work. Strychnin, however, was not known when the last edition of this chemist's work was put to press; and I have placed it where it is most probable Dr. Thomson would have placed it himself.

acid in a concentrated state. The acid appears to oxidize the strychnin, which, after being thus altered, still retains its salifiable property, though less alkaline in its nature. By the repeated action of nitric acid, it gradually becomes less and less alkaline and bitter, and at last loses its deleterious properties.

4. Strychnin is united, in the nux vomica and bean, with a peculiar acid, which is called, by its discoverers, igasuric acid, from the Malay name of the bean.

Its action upon animal life is that of an energetic poison.

5. Strychnin is a very violent poison. Half a grain of it, blown into the throat of a rabbit, killed the animal by tetanus in five minutes. Upon introducing the same quantity of the poison into an incision on the back of a rabbit, death was produced by tetanus in three minutes. The salts formed from this substance are found to be even more powerful; which circumstance is attributed to their solubility. Nitrate of strychnin, given to a rabbit in the dose of a quarter of a grain, caused tetanus in two minutes, and death in three more. Strychnin, when oxidized, becomes less poisonous, and by the repeated action of nitric acid is rendered at last harmless. Its effects are counteracted, in an eminent degree, by the use of opium. Majendie has given it a trial as a medicine, and observed the same effects from its use, as from that of the nux vomica, the bean, or the upas of Java; stimulating especially the spinal marrow, and inducing a true tetanus. It is, however, more powerful than these substances. When exhibited in doses of a quarter of a grain, in a case of muscular debility, occurring in a man of sixty years of age, in consequence of a cerebral disease, it induced several attacks of tetanus*.

SECTION III.

OF ASPARAGIN.

Asparagin, a peculiar substance extracted from asparagus.

1. Asparagin is the name given by Dr. Thomson to the peculiar vegetable substance, which was noticed by Vauquelin and Robiquet to be deposited in crystals, when the expressed juice of asparagus, evaporated to a syrup, is allowed to stand. These crystals are white and transparent, and have a cooling and slightly nauseous taste. They are very soluble in hot water, but sparingly so in cold. In alcohol they are insoluble.

* The facts given in the above section were taken from a paper on strychnin by Pelletier and Caventou, which appeared towards the close of the last year in the Annales de Chimie.

SECTION IV.

OF CERASIN.

1 Cerasin is the name, by which Dr. John distinguishes a peculiar vegetable substance, heretofore confounded with gum, and which possesses the following properties. It is harder than gum, but has the same appearance and taste as this vegetable substance. When put into water, it imbibes this liquid, and becomes transparent and gelatinous, but does not dissolve. It may be dissolved in boiling water, but it precipitates as the liquid cools. It is insoluble in alcohol and ether.

Cerasin has heretofore been confounded with gum.

2. The only vegetable substances, mentioned by Dr. Thomson as furnishing cerasin, are the gum tragacanth, and the different gums which exude from the cherry and plum trees, as well as from the almond and apricot.

It is furnished by gum tragacanth, which is the hardened juice of a tree.

3. Gum tragacanth is the juice, hardened in the sun, of the astragalus tragacantha, a thorny shrub, which grows in Candia and other islands of the Levant. It may be considered as pure cerasin. When put in water, it imbibes a large portion of this liquid, encreases in volume, and forms a jelly-like mass. By agitation, this mass may be so diffused, as to form a liquid, having the appearance of whey, and which, upon rest, becomes clear again. When a solution of gum arabic is poured into the whey-like liquid, so far from forming any union with the tragacanth, the latter subsides much faster than it otherwise would do. When treated with nitric acid, it yields abundance of saclactic acid.

4. The gummous exudations from the trees already mentioned are found by Dr. Thomson to be compounds of real gum and cerasin.

Gummous exudations are mixtures of gum and cerasin.

SECTION V.

OF INULIN.

1. Dr. Thomson has given this name to the peculiar substance, which Rose discovered in the roots of the inula helenium (elecampane.) It may be obtained by allowing their decoction to stand for several hours. The powder which will be found precipitated is inulin.

Inulin, a peculiar substance furnished by elecampane.

2. Inulin is insoluble in cold water, but may be diffused through this liquid, so as to have the appearance of milk. It is readily soluble in hot water. Alcohol produces no change in the aqueous solution when first added, but afterwards pre-

cipitates the inulin in the form of a bulky white powder. Gum, similarly treated, would remain milky for several days.

SECTION VI.

OF STARCH.

Starch; how obtained from wheat flour.

1. This peculiar vegetable substance may be readily obtained from wheat flour, by forming it into a paste with water, and kneading it continually under a stream of water, until this liquid runs off colourless. The water is found to have separated a portion of the flour, and to have assumed a milky appearance. Upon standing, it deposites a white powder. This powder is starch. What remains of the flour not affected by the stream of water is gluten, a substance which will be described hereafter.

Process pursued by the manufacturer.

2. Starch is obtained by the manufacturer by the following process. Wheat is steeped in cold water, until the grains have become so soft as to yield a milky juice when squeezed. It is then put into coarse linen sacks, and subjected to pressure in vats filled with cold water. The milky juice is in this way squeezed out of the grains, and becomes diffused in the water. The wheat is repeatedly steeped in water and subjected to pressure, as long as it yields any of the milky juice; after which the sacks and their contents are removed from the vats. The starch soon subsides, and the water which covers it gradually undergoes a fermentation, during which a portion of alcohol and vinegar is formed. The vinegar dissolves the impurities, and leaves the starch untouched. The supernatant liquid is then drawn off, and the starch washed, and dried at a moderate heat. During drying, it cracks into small columnar masses, possessing considerable regularity. It is now in the state in which it is used for stiffening linen and cotton cloth, and for other purposes.

Properties of starch.

3. Starch has a fine white colour, scarcely any smell, and very little taste. When exposed to air in a dry state, it undergoes no alteration. It is insoluble in cold water. With hot water, it may be formed into a kind of jelly, which can be diffused in boiling water, so as to remain suspended for a longer or shorter time, but does not dissolve. It is perfectly insoluble in alcohol, even when assisted by heat. It is insoluble also in ether. None of the salifiable bases, as far as they have been tried, is capable of precipitating it, except barytes. Its most characteristic property consists in its being thrown down, combined with tannin, from all solu-

tions by infusion of nutgalls. It constitutes a very delicate test of the presence of iodine. CHAP. I.

Effects of the stronger acids upon it.

4. Sulphuric acid dissolves starch slowly, and developes a very bulky charcoal. When diluted and heated, this acid dissolves it without alteration. Diluted nitric acid dissolves starch slowly, and forms a green-coloured solution, on the surface of which there swims a white matter, not acted upon by the acid. This peculiar mode of action of nitric acid has been taken advantage of, to detect starch in vegetables. Strong hydrochloric acid dissolves starch slowly, and without effervescence. When the proportion of the starch does not exceed $\frac{1}{20}$th of the acid, the solution is transparent and colourless; but when in larger amount, it loses, in a degree, its liquidity, and becomes of a brown colour.

5. When starch is thrown upon a hot iron, it melts, blackens, froths and swells, and burns with a bright flame, emitting a large quantity of smoke; but it does not explode, or emit the peculiar smell, which sugar does under similar circumstances.

Composition of starch.

6. According to an analysis by Gay-Lussac and Thenard, starch is composed of

Hydrogen	6·77
Carbon	43·55
Oxygen	49·68
	100·00

Starch is highly nutritious.

7. A very large proportion of the vegetables, employed as food by man, contain starch. It may, therefore, be justly considered a highly nutritious vegetable principle. Its medicinal properties are those of a demulcent. It is often advantageously used in diarrhœa and dysentery, both by the mouth and in the shape of clyster, more particularly in the latter form, when there is irritation in the rectum. The parts of plants, in which it is most abundantly found, are their seeds and bulbous roots. The following table exhibits the proportion of starch contained in one-hundred parts of the seeds, which constitute the greater portion of the vegetable food of man.

DIFFERENT VEGETABLE SEEDS.	Quantity of starch per cent.
Flour of wheat (triticum hybernum)	74·5*
rye (secale cereale)	62
barley (hordeum vulgare)	67†
Seeds of orysa sativa (rice)	from 84 to 85
pisum sativum (pea)	33
phaseolus vulgaris (kidney bean)	36

* According to Proust. Thomson's Annals xii. 202.

† I find by the Annals of Philosophy, that Proust has lately subjected barley

The potatoe contains 15 per cent. of starch, which differs from wheat starch.

8. The bulbous root of the potatoe (solanum tuberosum) was found by Einhof to yield 15 per cent. of starch. The method of obtaining it, is to grate down the potatoe to a pulp, and to wash it repeatedly with water on a fine sieve. The water carries with it the starch, and must be received in proper vessels and allowed to settle. This starch differs from wheat starch, in forming a thicker paste with water, in having a perceptible crystallized appearance, and in being specifically heavier.

9. The sago, salop and tapioca of the apothecaries, substances so frequently ordered as diet for the sick, are all different varieties of starch.

SECTION VII.

OF INDIGO.

Indigo, obtained from several plants.

1. Indigo of commerce is the produce of several species of plants, which grow in the West Indies and South America. These are the indigofera argentea, or wild indigo, the indigofera disperma, or Guatimala indigo, and the indigofera tinctoria, or French indigo. The first mentioned yields the best indigo, but in smallest quantity; the last named, the greatest.

Process described.

2. The indigo is separated from the plants by steeping them in water, until they undergo a species of fermentation, at which time, they communicate a green colour to the water. The water is drawn off and agitated, by which means blue floculi appear, and the whole becomes curdled. Lime water is now added, which is supposed to act by preventing putrefaction, and the floculi are allowed to subside. The water is then drawn off, and the pigment placed in linen bags to drain; after which, it is put into little square boxes and dried in the shade.

Indigo of commerce described.

3. The indigo of commerce is a light friable substance, of a deep blue colour and compact texture; its colour, however, varies somewhat with the different modes of its preparation. That which is lightest is most free from impurities, and is therefore best.

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to analysis, and finds it to contain only 32 per cent. of starch. This chemist conceives, that he has detected a new vegetable principle in this grain, in the amount of 55 per cent. which he calls hordeïn. (Annals, xii. 201.)

4. According to Bergman, the indigo of commerce is composed of

Pure indigo	47
Gum	12
Resin	6
Barytes lime and silica	22
Oxide of iron	13
	100

Thus it appears that more than half the weight of the indigo of commerce consists of impurities.

Pure indigo described.

5. Pure indigo is a soft powder of a deep blue colour inclining to purple, and destitute of taste or smell. It undergoes no alteration in the air. It is insoluble in water. When exposed to heat, it emits a bluish-red smoke, and at last burns with a faint white flame. The residuum is a portion of ashes.

Effects of the stronger acids upon it.

6. Diluted sulphuric acid, digested upon common indigo, has no other effect than to dissolve the impurities; but the same acid, when concentrated, dissolves pure indigo with the evolution of heat, and forms the solution, known by the name of liquid blue. Nitric acid, by its action upon it, produces tannin and bitter principle, and also, by peculiar management, benzoic acid.

SECTION VIII.

OF GLUTEN.

Gluten, how obtained from wheat flour.

1. This substance may be obtained from wheat flour, by forming it into a paste with water, and kneading it under a jet of water, until this liquid comes off colourless. The starch is thereby washed off, so that nothing remains but pure gluten.

Its properties.

2. Gluten is a ductile, exceedingly tenacious and elastic substance of a grey colour. When spread very thin, it is nearly white and has considerable resemblance to tendon or animal membrane. Its smell is peculiar, and its taste very slight. When exposed to the air, it at first assumes a brown colour, and becomes, as it were, covered by a coat of oil. Afterwards it becomes dry, in which state it has some resemblance to glue; for it is now slightly transparent, has a dark brown colour, and is pretty hard and brittle, breaking with a fracture like glass.

When fresh, contains water.

3. Gluten in its fresh state always contains a certain quantity of water, which it holds with great obstinacy, and to which it owes its elasticity and tenacity. When macerated in cold water for a considerable time, an opaque liquid, suspending small films, is formed. This liquid, by repeated

filtration, may be rendered transparent, but still it contains a small proportion of gluten. From this it appears, that this vegetable substance is somewhat soluble in water. When the transparent solution is heated, the gluten separates in yellow flakes.

Moist gluten putrefies upon keeping.

4. When gluten is kept moist, it very soon undergoes a kind of putrefactive fermentation. It swells, emits bubbles of air consisting of hydrogen and carbonic acid, and exhales a putrid odour, similar to that which attends the putrefaction of animal substances. When continued in the same state for 24 days, the gluten becomes converted into a kind of paste, of a greyish-white colour, which is denominated fermented gluten. If the exposure be still continued, the gluten at last acquires the smell and taste of cheese.

5. Fresh gluten does not dissolve in alcohol, but is thrown down from its aqueous solution by this liquid. It is insoluble in ether also.

Effects of the stronger acids upon gluten.

6. Concentrated sulphuric acid, when poured upon gluten, renders it at first violet-coloured, but at last black; inflammable air is evolved, and water, ammonia and charcoal formed. When nitric acid is heated upon it, azotic gas is evolved, oxalic and malic acids are formed, and a number of yellow-coloured oily flakes make their appearance. When the infusion of nut-galls is added to a solution of gluten, a yellowish-brown precipitate appears, which does not dissolve by the application of heat.

Effects of drying and of heat.

7. When moist gluten is suddenly dried, it swells exceedingly. When dry gluten is exposed to heat, it cracks, swells and melts, then blackens and exhales a fetid odour, burning precisely like feathers or horn.

Gluten resembles animal matter.

8. Gluten approaches, in many respects in its nature, to animal matter. Yielding ammonia by destructive distillation and by fermentation, one of its constituents must be azote. Its other component parts are oxygen, hydrogen and carbon.

It is found in a great variety of highly nutritious substances.

9. Gluten, besides existing in large proportion in wheat flour, which is thereby so well fitted to form bread, is found in many other nutritious vegetable substances, in greater or less amount. The principal of these are rye, barley, peas, and beans, as well as chesnuts, horse-chesnuts and acorns. It has not been discovered in the potatoe. After being fermented, it forms, by trituration with a small quantity of alcohol and afterwards mixture with a considerable quantity, a solution, which constitutes an excellent varnish for paper or wood, as was first ascertained by Cadet. This same chemist ascertained, that fermented gluten formed a very good ground for paint. It is also useful for the purpose of cementing pieces of china.

SECTION IX.

OF POLLENIN.

1. THIS is the name given by Dr. John to a peculiar substance, which may be extracted from the pollen of the pinus abies, pinus sylvestris and lycopodium clavatum, and which is supposed by him to be the characteristic constituent of the pollen of every species of plant.

Pollenin, a peculiar substance extracted from the pollen of the pine.

2. Pollenin is a yellow substance, destitute of taste and smell. It is insoluble in water, alcohol, ether or the oils. When exposed to the air, it very soon acquires the odour and taste of cheese, and afterwards runs into the putrefactive fermentation, forming a considerable quantity of ammonia. It is closely allied to gluten in its properties.

SECTION X.

OF FIBRIN.

1. FIBRIN must always be considered as a substance rather of animal than of vegetable origin. But as a substance has been detected by Vauquelin in the milky juice of the papaw tree (carica papaya), which appears to be the same as the fibrin of the blood; fibrin, although previously considered exclusively of animal origin, must be mentioned here to complete the enumeration of vegetable proximate constituents. The description of this substance will be deferred, until treating of fibrin as an animal constituent.

Fibrin exists in the juice of the papaw tree.

THIRD SET.

SUBSTANCES WHICH MELT WHEN HEATED, IF NOT ALREADY LIQUID, AND BURN LIKE OILS.

SECTION I.

OF OILS.

1. THIS class of vegetable constituents has been divided into fixed and volatile oils.

Oils are divided into fixed and volatile.

2. The fixed oils are found very rarely in any parts of vegetables except their seeds, which are almost always bicotyledonous. Olive oil is an exception to this rule, being extracted from the pulp which surrounds the stone of the fruit. On the other hand, the volatile oils are found in every part of the plant, except the cotyledons of the seeds.

 These latter oils are very numerous, existing in fact in all plants having a peculiar odour, which in every case depends upon their presence. Some account of the volatile and fixed oils has already been given. The subject is resumed merely for the purpose of making the enumeration of the proximate constituents of vegetables complete.

SECTION II.

OF WAX.

Wax may be extracted from several plants.

1. Wax may be extracted in considerable abundance from several plants. The greatest quantity of this substance, however, is fabricated by bees from vegetable materials. Bees-wax will be first described, and afterwards the principal varieties of this substance will be noticed.

Bees-wax described.

2. Bees-wax, when pure, is of a whitish colour, and nearly destitute of taste and smell. In its common state, it is yellow, and has a pretty strong aromatic odour; but it loses both colour and smell by bleaching, which is effected by exposing the wax, in thin ribands, for some time to the atmosphere. It is insoluble in water and in cold alcohol; but alcohol, assisted by heat, is capable of dissolving $\frac{1}{20}$th of its weight of it. When the solution cools, the greater part of the wax falls down, and the remainder may be precipitated by water. Dr. John has ascertained, that one portion of bees-wax is insoluble in boiling alcohol, and has properties distinct from the soluble portion. The insoluble portion he calls *myricin*, and the soluble portion, *cerin*.

Wax combines with fixed oils.

3. Wax combines readily with fixed oils, and forms compounds of more or less consistency, according to the proportions used. This combination forms the application made to sores, which is known by the name of cerate.

4. Wax combines with potash, soda and ammonia, and forms compounds analogous to soaps.

5. Acids have but little action upon wax. Chlorine produces no other change upon it than to destroy its colour, when in the unbleached state. Its insolubility in acids fits it as a lute to confine corrosive acids, and for stopping bottles containing these substances.

Composition of wax.

6. According to Gay-Lussac and Thenard, wax is composed of

Oxygen	5·544
Hydrogen	12·672
Carbon	81·784
	100·000

7. It has been ascertained, that the varnish, which covers the upper surface of the leaves of many plants, consists of a substance, which possesses all the properties of bees-wax. It may be separated by the following process: Digest the bruised leaves, first in water and then in alcohol, until every thing soluble is taken up. Treat the residuum with six times its weight of water of ammonia, as long as this liquid will dissolve any thing. Then decant the solution formed, and, after filtering it, add diluted sulphuric acid, more than sufficient to saturate the ammonia, stirring the whole constantly. A precipitate, in the form of a yellow powder, will fall, which, after being carefully washed, and melted over a gentle fire, is the substance in question.

Varnish, covering some leaves, is a kind of wax.

8. Myrtle wax is obtained from the myrica cerifera, a shrub which grows abundantly in Louisiana and other parts of the United States. The wax is separated by boiling the berries, which are covered with a coat of it, in water. The boiling water melts the wax, which is skimmed off its surface. It is then passed through a cloth, dried, melted again, and cast into cakes. This wax is insoluble in water, and but sparingly soluble in alcohol. Its specific gravity is greater than that of bees-wax. It forms compounds with potash, soda and ammonia, very similar to those formed by bees-wax. When strongly heated, it burns with a clear white flame, emitting an aromatic odour.

Myrtle-wax.

9. Wax is of indispensable utility in pharmacy. It enters into the composition of almost all the cerates, ointments and plasters, employed in practice.

Uses of wax in pharmacy.

SECTION III.

OF CAMPHOR.

1. Camphor is obtained from the laurus camphora, a tree which grows in Japan, and other parts of Asia. It comes to Europe and America in a crude state, formed by distilling the wood of the plant with water. It is refined for the purposes of medicine by a second distillation in glass vessels.

Camphor, obtained from a tree which grows in the east.

2. Camphor, after being refined, is a white brittle substance, possessing a strong acrid taste, and peculiar aromatic smell. It is insoluble in water, but dissolves readily in alcohol, from which it may be precipitated by water. It is soluble also in both fixed and volatile oils. It is not acted on by potash or soda, whether pure or in the state of carbonates.

Its properties.

3. Most of the acids dissolve camphor, and generally it may be precipitated from their solutions unaltered.

4. When camphor is exposed in an open vessel in warm weather, it evaporates completely. It is volatilized also, when exposed to heat; but if the heat be suddenly applied, it may be melted before it evaporates. It is very inflammable, catching fire readily and emitting a great deal of flame, and leaving no residuum. When burnt in a large globe filled with oxygen gas, and containing a little water, the products are camphoric acid and carbonic acid which impregnate the water, and charcoal which covers the inner surface of the globe.

5. There are several kinds of camphor, besides that which has just been described. The principal of them are the camphor of volatile oils, and the camphor formed by treating oil of turpentine with hydrochloric (muriatic) acid.

Camphor of volatile oils.

6. The camphor of volatile oils exists in almost all these bodies. It may be obtained by subjecting them to various degrees of cold, exposed to the open air: the oil gradually evaporates, and the camphor is left behind.

Artificial camphor, formed by the action of hydrochloric acid on oil of turpentine.

7. Artificial camphor is made by passing hydrochloric acid gas into a vessel containing oil of turpentine. The gas is absorbed, and the oil becomes hot, is increased in bulk, and its colour changed to dark brown. After standing for 24 hours, the oil deposites crystals of artificial camphor. These crystals at first have a slight odour of oil of turpentine. To remove this smell, they must be sublimed, mixed with their weight of charcoal powder, wood-ashes or quicklime.

Properties of artificial camphor.

8. When thus purified, artificial camphor has a smell resembling that of common camphor, but not so strong. Its taste also is similar to that of common camphor. It swims on water, and may be burnt upon its surface, as is the case with natural camphor. It dissolves completely in alcohol, from which it may be precipitated by water. Nitric acid of the specific gravity of 1·261 has no action upon it, although this acid dissolves readily common camphor. Concentrated nitric acid, however, dissolves it with the emission of deutoxide of azote (nitrous gas), and the solution formed is not precipitated by the addition of water. Hence it would appear, that artificial camphor resembles common camphor in every particular, except in the action of nitric acid.

SECTION IV.

OF BIRD-LIME.

1. THE viscid matter, which covers the epidermis of the robinia viscosa, has been ascertained by Vauquelin to be a peculiar vegetable substance. The substance called bird-lime, by an analysis of Bouillon la Grange, is found to owe its peculiar properties to the presence of a body, very analogous to the peculiar viscous principle just mentioned. It is on this account, that Dr. Thomson proposes to call the vegetable principle itself by the name of *bird-lime*. Bird-lime, obtained from a species of robinia.

2. The bird-lime, which exudes spontaneously from plants, is a green adhesive substance, destitute of taste or smell. It softens between the fingers, to which it sticks with great obstinacy. It is insoluble in water, and in alcohol when cold; but it dissolves in hot alcohol. It combines readily with oils. Ether dissolves it with facility, without the assistance of heat. Its properties.

3. Artificial bird-lime is usually prepared from the middle bark of the holly. This bark, after being boiled six or eight hours until it becomes soft, is laid in the earth, covered with stones, to undergo fermentation, by which it assumes a mucilaginous consistency. Artificial bird-lime, obtained from the holly.

SECTION V.

OF RESINS.

1. RESINS are peculiar substances, which flow spontaneously, or through artificial openings from trees, not uncommonly mixed in the first instance with volatile oils. They possess the following properties: Resins, whence obtained.

2. They are brittle substances, of a yellow colour, and possessing a certain degree of transparency. They have a taste, which is more or less acrid, and no smell, unless they contain foreign bodies. They are all heavier than water. When exposed to heat, they melt; and, if the temperature be increased, they catch fire and burn with a yellow flame, emitting a vast quantity of smoke. They are insoluble in water, but dissolve with few exceptions in alcohol, especially when assisted by heat. When the alcoholic solution is mixed with water, they are precipitated in the form of a white powder, which at first renders the solution milky. They are soluble also in sulphuric ether. The greater number of them dissolve in oil of turpentine. Solutions of potash or soda, Their general properties.

either pure or in the state of carbonates, dissolve them perfectly at a boiling temperature; and the compounds formed have the properties of soap, and may be used as detergents. They are taken up but imperfectly by ammonia. The action of sulphuric and nitric acids is to dissolve, and afterwards, by the assistance of heat, to convert them into tannin. If the action of the first named acid be allowed to go on to its fullest extent, they are converted into charcoal. Hydrochloric acid and acetic acid dissolve them slowly, and form solutions, from which they may be precipitated by water.

Resins are of various kinds.

3. Having given their general properties, it is next proper to describe some of the individual resins. Those which will be noticed here are the following; namely, rosin, mastich, tacamahac, animé, copal, lac, and amber.

1. Rosin exists in several turpentines, which are composed of rosin and oil of turpentine.

[1.] *Rosin.* The resinous juice which exudes from different species of fir is called turpentine. That obtained from the pinus sylvestris (common Scotch fir) and pinus abies (spruce fir) is denominated common turpentine; that from the pinus larix, venice turpentine; and that from the pinus balsamea, balsam of Canada. All these turpentines are composed of two constituents, which may be separated by distillation; namely, oil of turpentine, which distils over, and rosin, which remains behind. Rosin furnishes a very perfect example of a resin; and the general properties of the resins, already detailed, may be considered as those belonging to this substance.

According to Gay-Lussac and Thenard, rosin is composed of

Oxygen	13·337
Carbon	75·944
Hydrogen	10·719
	100·000

2. Mastich.

[2.] *Mastich.*—This resin exudes, by transverse incisions, from a tree, which grows in the Levant, and is called by the botanists pistacea lentiscus. It is in the form of transparent, yellow, brittle grains. Its taste is slight, but not unpleasant. It has been long used in Turkey, as a masticatory, with the view of strengthening the gums and sweetening the breath. When heated, it emits a fragrant odour. The action of different chemical bodies proves it to possess the general properties of a resin.

3. Tacamahac.

[3.] *Tacamahac.*—This is the produce of an American plant, called fagara octandra. It is in the form of oblong masses, wrapt in flag leaves, possessing a light brown colour. It is very brittle. When heated it easily melts. In its pure state, its smell is intermediate between that of lavender and

musk. It is entirely soluble in alcohol, but insoluble in water. CHAP. I.

[4.] *Animé.*—This resin is obtained from the hymenæa courbaril, or locust tree, a native plant of North America. It resembles very much copal, and is said to be frequently employed in making varnishes. It is easily distinguished from copal by its ready solubility in alcohol. 4. Animé.

[5.] *Copal.*—This resinous substance is said to be obtained from the *thus copallinum*, a native tree of North America. The best kind of copal comes from Spanish America. It is a beautiful white substance with a slight tint of brown. It is frequently opaque, but sometimes perfectly transparent. It agrees with the other resins in its fusibility by heat, its solubility in alkaline salifiable bases, and in the changes produced upon it by the action of nitric acid. On the other hand, it differs from them, in not being soluble in alcohol or oil of turpentine without peculiar management, and in not being so readily soluble in the fixed oils. 5. Copal obtained from the thus copallinum.

When a solution of copal in some volatile liquid is spread with a brush upon wood, metal, paper, &c. after the volatile menstruum has evaporated, there remains upon these bodies a thin layer of copal perfectly transparent. It is in this way, that copal is prepared for a varnish, and it certainly constitutes the most beautiful application of this kind known. The menstrua for copal, which are most generally employed, are oil of turpentine, linseed oil, or a mixture of these liquids. Forms a beautiful varnish.

[6.] *Lac.*—This substance has already been noticed, when describing the laccic acid. It is formed upon the twigs of different trees, which grow in the East Indies, and constitutes the nidus of an insect called chremes lacca. In commerce, it is distinguished into different kinds. When encrusting small twigs, it is of a red colour, and is called stick-lac. When boiled in water, it loses its red colour, and is then called seed-lac. When melted and formed into a thin crust, it is called shell-lac. The two last mentioned kinds are brown. By an analysis of Hatchett, it appears, that these substances are composed principally of resin; stick-lac containing 68 per cent., seed-lac 88 per cent., and shell-lac 91 per cent. of resin. The other constituents are colouring matter having the properties of extractive, wax resembling myrtle wax, and gluten, analogous to that furnished by wheat. 6. Lac, the nidus of an insect.

Lac is applied to several uses in the arts. It is dissolved by a solution of subborate of soda (borax.) When the solution is made of one hundred grains of lac, in four ounces of water containing twenty grains of this salt, and then mixed with lampblack, it constitutes Indian ink. Melted with dif- Uses of lac.

ferent proportions of turpentine, and ivory black or vermilion, it constitutes black or red sealing wax. It forms also the basis of many varnishes and lackers.

7. Amber is of vegetable origin.

[7.] *Amber.*—This substance possesses most of the properties of a resin, and may, without impropriety, be placed among these bodies. It is undoubtedly of vegetable origin. It is found in different countries, but most abundantly in Prussia, on the sea shore, or under the earth at the depth of about one hundred feet, resting on wood coal. It is a light, brittle, hard substance, sometimes perfectly transparent and nearly colourless, but commonly semi-transparent, and yellow or deep brown. It has considerable lustre, and is susceptible of polish. It breaks with a glassy fracture. It is tasteless, and without smell unless when pounded or heated. It may be melted, but it always loses weight in this operation. In a strong heat, it burns and leaves a small portion of ashes. It does not dissolve in water, and is but sparingly soluble in alcohol. Nitric acid produces the same changes on it as upon resins in general.

Its properties.

SECTION VI.

OF GUAIACUM.

Guaiacum, obtained from a tree of the West Indies.

1. This substance is obtained from a native tree of the West Indies, called by botanists, guaiacum officinale. It exudes spontaneously, but is generally forced out artificially, by heating one extremity of billets of the wood, bored longitudinally. The guaiacum is thereby melted, and runs out of the other extremity.

Its properties.

2. Guaiacum is a solid substance, having considerable resemblance to a resin. Its colour is not uniform, but different portions of it are reddish, brownish, or greenish. It is somewhat transparent, and breaks with a vitreous fracture. When pounded, it emits a pleasant odour, and although it possesses scarcely any taste, yet it produces a burning sensation in the throat. When heated, it melts and exhales a peculiar odour. It was confounded with the resins, until Hatchett observed, that its products by the action of nitric acid were not those of a resin. This chemist ascertained, that no tannin was formed by nitric acid on guaiacum; but a large quantity of oxalic acid. This circumstance is sufficient to distinguish guaiacum from the resins.

SECTION VII.

OF BALSAMS.

1. THE term balsam was originally applied to all thick liquids, possessing a strong and fragrant smell. Its meaning was afterwards restricted by chemists to resinous-like substances, which yield benzoic acid when exposed to heat. In this latter sense, the term balsam will be taken here. Term balsam, used in various meanings.

2. It has generally been supposed by chemists, that the benzoic acid, which the balsams yield by heat, exists in them ready formed; but Hatchett has rendered it probable, that it is produced during its separation. By the definition given of the balsams, it is obvious that they may exist either in the liquid or solid form; and accordingly Dr. Thomson has divided them into liquid and solid balsams. Balsams divided into liquid and solid balsams.

3. The liquid balsams at present known are the balsams of Gilead (opobalsamum), of copaiva, of Tolu, of Peru, and of styrax. These substances will be noticed in the order in which they have been named. Liquid balsams are

[1.] *Balsam of Gilead.*—This balsam is the product of the amyris gileadensis, a tree which grows in Arabia. It is held in high estimation by the Turks; and from its scarcity, and the difficulty of procuring it genuine, very little is known respecting its properties. 1. Balsam of Gilead.

[2.] *Balsam of Copaiva.*—This balsam is obtained by incision from a tree, which grows in South America and the West Indies, called by botanists copaifera officinalis. It is a transparent liquid, of a yellow colour, possessing an agreeable smell and pungent taste. It is not known to yield benzoic acid; hence in strict propriety it ought not to be classed among the balsams. 2. Balsam of copaiva.

[3.] *Balsam of Tolu.*—This balsam is obtained by incision from the toluifera balsamea, a tree of South America. It occurs in commerce, contained in small gourd shells. It has a reddish-brown colour, and a thick tenacious consistence. When exposed to the air, however, it becomes hard and brittle. It has a fragrant smell. When distilled, it yields benzoic acid. 3. Balsam of Tolu.

[4.] *Balsam of Peru.*—This balsam is obtained from the moroxylon peruiferum, a tree which grows in South America, by boiling the twigs in water. It has the consistency of honey. It possesses a brown colour, an agreeable smell and an acrid taste. 4. Balsam of Peru.

[5.] *Balsam of Styrax.*—This is the product of the liquidambar styraciflua, a tree which grows in Virginia, Mexico, and other parts of North America. It is obtained by boil- 5. Balsam of Styrax.

ing the bark of the tree in salt water to the consistence of bird-lime. It has a greenish colour, an aromatic taste, and agreeable smell. When treated with water, benzoic acid is dissolved. It is completely soluble in alcohol, except impurities.

The solid balsams are,

4. The solid balsams are benzoin, storax, and dragon's blood. They will be noticed in the following paragraphs.

1. Benzoin.

[1.] *Benzoin.*—This balsam is obtained by incision from the styrax benzoe, a tree which grows in Sumatra. It is a brittle substance, usually in the form of yellowish-white tears joined together by a brownish matter, but sometimes of a brown colour, having some resemblance to common rosin. It has very little taste, but an agreeable smell when heated. Cold water has very little action upon it; boiling water, however, dissolves a portion of benzoic acid. Alcohol, by the assistance of heat, effects its solution, which has a deep yellow colour, inclining to reddish-brown.

2. Storax.

[2.] *Storax.*—This balsam is obtained by incision from the styrax officinalis, a tree which grows in the Levant. It also grows in Italy and France, but the heat of these countries is not sufficient to cause the plant to yield the balsam. It is obtained from the tree in the form of red tears, but occurs in commerce in large masses, which are brittle, although soft to the touch, and of a reddish-brown colour. It is generally mixed with a quantity of sawdust. It agrees with benzoin in constituents, but contains a smaller proportion of benzoic acid.

3. Dragon's blood.

[3.] *Dragon's Blood.*—Almost all the dragon's blood used in medicine comes from the East Indies, and is the produce principally of the calamus draco. It is also furnished by the pterocarpus draco, a native tree of South America, whence it was formerly frequently exported to Spain. It is a brittle, tasteless, inodorous substance, insoluble in water, but almost entirely soluble in alcohol. The alcoholic solution is of a fine deep red colour, and is sometimes used to stain marble. It is fusible and combustible. By the action of nitric acid, it is converted into benzoic acid and artificial tannin.

SECTION VIII.

OF GUM-RESINS.

Characters of the gum-resins.

1. THE gum-resins may be distinguished by the following characters: they are solid and usually brittle substances, of a fatty appearance, and opaque or but imperfectly trans-

parent. They are not fusible as the resins are, neither are they so combustible. When exposed to heat, they soften and melt. Almost all of them have a strong smell, and an acrid taste. They are but partially soluble in water, with which they form a permanent mixture, always opaque, and generally of a milky appearance. They form with alcohol, transparent solutions, which are rendered turbid by the addition of water. The strong acids convert most of them into tannin and charcoal. They are usually specifically heavier than the resins. They have been considered to be composed of gum and resin; but all their properties do not accord with such a supposition. They all contain a volatile oil, or a substance intermediate in properties between an oil and a resin. It is to this constituent of them, that their property of forming an opaque solution with water is to be ascribed.

The best known of the gum-resins are the following: The chief gum-resins are

[1.] *Galbanum*.—This substance is the milky juice, hardened by exposure to the air, of the root of the bubon galbanum, a native plant of Africa. It is brought from the Levant in pieces, composed of tears agglutinated together, which have a yellowish or white colour. It has an acrid and bitter taste, and a peculiar smell. It forms a milky solution with water. It is partially soluble in alcohol. 1. Galbanum.

[2.] *Ammoniac*.—This substance, which is brought from the East Indies, is the produce of an unknown plant. It is composed of small pieces agglutinated together, and has a yellowish-white colour. It has a nauseous sweet taste, mixed with some bitterness. Its smell resembles that of galbanum, but is more pleasant. Part of it is soluble in water, with which it forms a milky solution. More than half its weight dissolves in alcohol. 2. Ammoniac.

[3.] *Aloes*.—This gum-resin is the inspissated juice of a variety of the aloes perfoliata, a plant which grows in the island of Socotora in the East Indies. It has a resinous appearance, a reddish-yellow colour, a bitter taste, and an aromatic smell. It has been found by Braconnot to contain a peculiar principle, similar to that which was detected by Vauquelin in the febrifuge barks. 3. Aloes.

[4.] *Olibanum*—(*Frankincense*.)——This gum-resin is brought from Arabia and India. That from Arabia is most esteemed. It remains doubtful what plant yields this substance. It is brittle and semi-transparent, has a whitish-yellow colour, and an acrid and aromatic taste. When burnt, it diffuses an agreeable odour. When heated, it melts with difficulty, but burns with brilliancy, leaving some white ashes. 4. Olibanum.

5. Sagapenum. [5.] *Sagapenum.*—It is not certainly known what plant yields this gum-resin. The substance itself is brought from Alexandria, and is composed of tears agglutinated together. It has a yellow colour, a hot and bitter taste, and an alliaceous smell. It is but sparingly soluble in water, but dissolves almost entirely in alcohol.

6. Assafœtida. [6.] *Assafœtida.*—This is the hardened juice of the root of the *ferula assafœtida*, a native plant of Persia. It occurs in commerce, in the form of small grains of different colours, as whitish, reddish, violet and brown. It has an acrid and bitter taste, and a strongly alliaceous and fetid smell. It is in part soluble both in water and in alcohol.

7. Scammony. [7.] *Scammony.*—This gum-resin is the hardened juice of the roots of the convolvulus scammonia, a climbing plant of Syria. It has a dark-grey colour, a peculiar and nauseous smell, and an acrid and bitter taste. It forms with water a greenish opaque solution. The greatest part of it is dissolved by alcohol.

8. Opoponax. [8.] *Opoponax.*—This gum-resin is obtained by wounding the roots of the pastinaca opoponax, a native plant of the countries surrounding the Levant. It is in lumps of a reddish-yellow colour on the surface, but white within. It has a bitter and acrid taste, and a peculiar smell. About one half of it dissolves in water, with which it forms a milky solution. It is acted upon but feebly by alcohol.

9. Gamboge. [9.] *Gamboge.*—This gum-resin is the produce of the stalagmitis gambogioides, a tree which grows wild in Siam and Ceylon. In Siam, it is obtained by wounding the shoots, but in Ceylon, it exudes from wounds in the bark. It is in the form of yellow cakes, which are opaque and brittle, and break with a vitreous fracture. It has no smell, and very little taste. It forms with water a yellow turbid liquid. It is almost completely soluble in alcohol.

10. Myrrh. [10.] *Myrrh.*—It is not ascertained what plant furnishes myrrh. It is, however, known to grow in Abyssinia and Arabia. It is in the form of tears, of a reddish-yellow colour. It has a peculiar smell, and an aromatic bitter taste. It forms with water a yellow opaque solution. The alcoholic solution becomes opaque upon the addition of water, but no precipitate subsides.

SECTION IX.

OF CAOUTCHOUC.

(Commonly called, *Indian Rubber.*)

1. THIS peculiar substance first came into notice about the beginning of the last century. Some account of it was sent, in 1736, to the French academy by Condamine, one of the academicians, who went to South America to measure a degree of the meridian. It is the produce principally of two trees of South America; the hœvea caoutchouc and the jatropha elastica. When these trees are punctured, they yield a milky juice, which, by exposure to the air, lets fall a concrete substance. This substance is caoutchouc. Caoutchouc is the product of several trees of South America.

2. Caoutchouc is a soft and pliable substance, destitute of taste or smell, and exceedingly elastic and adhesive. When perfectly pure, it is white. In its common state, it has a blackish colour, owing to the manner in which it is dried. This consists in spreading a thin layer of the milky juice over a mould formed of clay, and then exposing it to the action of smoke, which gives it a thin coating of soot. Another layer of the juice is then applied and dried in the same way, and so on for any number of layers, until the coat has the requisite thickness. Caoutchouc is not altered by exposure to the air. It is perfectly insoluble in water, but if boiled for some time in this liquid, it becomes somewhat transparent, owing to the abstraction of the sooty matter, and so soft, as that two pieces when pressed together may be welded into one. This property, which it possesses, enables the artist to form tubes of it with facility; for if a slip of it, of uniform thickness, be wound spirally round a glass or metallic rod, so that its edges touch accurately, and then boiled for some time in water, the whole will agglutinate so as to form a tube. Its properties.

3. Caoutchouc is insoluble also in alcohol. Ether, however, dissolves it, if it be previously subjected to washing; which operation seems to act by separating a portion of alcohol, and substituting for it a small quantity of water. From this solution, the caoutchouc may be obtained by evaporation unaltered; and hence, by taking advantage of this menstruum, it may be formed into different instruments. For common purposes, however, this solvent is too expensive to be employed. It is soluble, without alteration also, in rectified petroleum. In volatile oils it dissolves, but when obtained again by evaporation from them, it is altered in its properties; being rendered glutinous, and consequently unfit for most of the uses to which it is applied. It is insoluble in alcohol, but soluble in ether.

It is soluble also in ammonia, potash, or soda.

4. Dr. Thomson has found, contrary to what was formerly supposed, that caoutchouc combines with some of the alkaline salifiable bases. This chemist accidentally discovered, while making some experiments, that ammoniacal gas was absorbed when contained in a bottle of this substance. It was at the same time ascertained, that if the caoutchouc was allowed to absorb successive portions of the gas, it lost its elasticity, and became soft and glutinous. Dr. Thomson afterwards found, that both potash and soda dissolved a small portion of caoutchouc, producing the same changes.

5. Sulphuric acid, after long digestion, chars caoutchouc superficially, but there is no trace of artificial tannin formed. When treated with nitric acid, it yields azotic gas, carbonic acid gas, and hydrocyanic acid gas. Hydrochloric acid has no action upon it.

6. When exposed to heat, it readily melts; whereby it is changed in its properties, having always afterwards the consistence of tar. When heated sufficiently, it burns with a bright flame emitting a fetid odour.

Constituents of caoutchouc.

7. Caoutchouc is composed of carbon, hydrogen, azote and oxygen, but combined in what proportion is not known.

FOURTH SET.

SUBSTANCES, INSOLUBLE IN WATER, ALCOHOL OR ETHER, AND HAVING A FIBROUS TEXTURE.

SECTION I.

OF COTTON.

Cotton, obtained from several species of plants.

1. Cotton is the soft down, which envelopes the seeds of various plants, especially several species of gossypium, the genus which furnishes the cotton of commerce. Very little is known respecting the chemical nature of cotton, but sufficient has been ascertained to demonstrate its peculiar nature.

Its properties.

2. Cotton is a substance, composed of very fine fibres, possessing neither taste nor smell. It is somewhat different in its colour, according to the variety of the plant from which it is obtained, but is capable of being rendered of a beautiful white by bleaching. It is completely insoluble in water, alcohol, ether, the oils, and all the vegetable acids. In diluted solutions of potash or of soda, it is insoluble; but these solutions, when concentrated and assisted by heat, dissolve it. It is capable of combining with oxide of iron,

and oxide of tin, when dipped into solutions of these metals. It combines also with tannin, when immersed in an infusion of nut-galls, or other astringent vegetable substance. Hence the use of all these substances in dyeing.

3. Nitric acid, when assisted by heat, converts cotton into oxalic acid. Sulphuric acid developes charcoal. Chlorine, if not too much concentrated, bleaches it.

SECTION II.

OF SUBER.

1. COMMON cork, the outer bark of the quercus suber, has been ascertained to possess peculiar chemical properties, and suber is the name by which chemists distinguish it. *Suber or cork, a peculiar vegetable substance.*

2. Suber is a light, soft, elastic substance, which burns with a bright white flame, leaving a black bulky charcoal. When distilled, it yields ammonia. By the action of sulphuric acid, it is converted into charcoal; and by nitric acid, into suberic acid, a substance resembling wax, artificial tannin, and a kind of starchy matter.

SECTION III.

OF MEDULLIN.

1. DR. JOHN gives this name to the pith of the helianthus annuus (sun-flower), of the cyringa vulgaris, and some other plants. It is found to be a peculiar substance, possessing the following properties. *Medullin, obtained from the pith of several plants.*

2. It is inodorous and tasteless, and insoluble in water, ether, alcohol, and the oils. It has a peculiar porous structure. It forms oxalic acid, but no suberic acid, by the action of nitric acid. By distillation, it yields ammonia, and the residuum is a charcoal, which has a metallic appearance and some resemblance in colour to bronze.

SECTION IV.

OF LIGNIN.

1. IF the vegetable substance, commonly called wood, be well dried, and then digested first in water, and afterwards in alcohol, until every thing soluble in these liquids is taken up, what remains will be lignin or woody fibre. *Lignin; how obtained.*

PART II. BOOK II.

Its properties. 2. It is composed of longitudinal fibres, somewhat transparent, and destitute of taste or smell. It is insoluble in water or in alcohol. Solutions of potash or of soda, when assisted by heat, decompose it, rendering it soft, and changing its colour to a deep brown. Weak solutions of the same alkaline bases dissolve it, and it may be thrown down from them unaltered by means of an acid. When exposed to heat, it blackens without melting or frothing, exhales an acrid fume, and leaves a charcoal exactly the shape of the lignin employed. When distilled, it yields an acid liquor, formerly considered peculiar under the name of the pyrolignous acid, but which is ascertained by Fourcroy and Vauquelin to be the acetic acid, combined with empyreumatic oil. By means of some substance, which Dr. Thomson considers to be animal charcoal, the empyreumatic oil may be separated, and very good vinegar obtained from this acid liquor. Vinegar is in this way manufactured both in Britain and France.

Its composition. 3. According to Gay-Lussac and Thenard, lignin from the oak is composed of

Oxygen	41·78
Carbon	52·53
Hydrogen	5·69
	100·00

4. It has been found, that the lignin of all the vegetables yet examined is very nearly the same. When wood is burnt with a smothered flame, a quantity of charcoal is formed, and this is entirely evolved from the lignin. Hence then the quantity of charcoal, which different woods yield, will indicate the proportion of their lignin.

SECTION V.

OF FUNGIN.

Fungin, how obtained. 1. BRACONNOT has given this name to the substance, which remains after the mushroom has been deprived of every thing soluble either in water or alcohol.

Its properties. 2. It is a soft, white, insipid substance, possessing but little elasticity. It is insoluble in water, alcohol, ether, and the oils. Solutions of potash or of soda, when diluted, have but little action upon it; but when concentrated and assisted by heat, they dissolve it, so as to form a saponaceous liquid, from which it may be precipitated again by acids.

FIFTH SET.

SUBSTANCES, FOUND IN PLANTS, WHICH BELONG RATHER TO THE MINERAL THAN VEGETABLE KINGDOM.

SECTION I.

CHLORIDES AS FOREIGN INGREDIENTS.

THE chlorides which have been found in plants are the chlorides of potassium (muriate of potash), of sodium, (common salt), and of magnesium (muriate of magnesia). Chloride of potassium is usually a constituent in vegetable ashes. Chloride of sodium is present in all plants, which vegetate on the sea or near the sea shore. Chloride of magnesium has been detected in some of the fuci, and will not improbably be found as a constituent in most marine plants. Several chlorides have been found in plants.

SECTION II.

ACIDS AS FOREIGN INGREDIENTS.

THE foreign acids found in plants are the sulphuric, nitric, carbonic and phosphoric acids. They are usually combined with bases in the form of salts. United with lime, sulphuric acid exists in clover. Nitric acid has been found, combined with potash in the sun-flower, and with soda in barley. Carbonic acid, combined with potash, is found in the ashes of almost all vegetables. Phosphoric acid exists in a free state in the onion; it is present, in union with lime, in all kinds of grain, and combined with potash in barley. List of foreign acids found in plants.

SECTION III.

SALIFIABLE BASES AS FOREIGN INGREDIENTS.

THE salifiable bases heretofore found in plants are potash, soda, lime, magnesia, alumina, silica, oxidized iron, and oxidized manganese. Salifiable bases found in plants are,

I. Potash is a constituent of almost all vegetables, which grow at a distance from the sea. Vauquelin has made it probable, that it exists in them combined either with acetic or carbonic acid. It is obtained by burning plants, which dissipates every thing but their alkaline and earthy constituents. The residuum is called the ashes, from which the potash may be obtained by lixiviation; it being soluble while 1. Potash.

PART II. BOOK. II.

the other bases are not. It may be obtained from some plants, without the aid of incineration, as has been lately ascertained by Peschier of Geneva. The plan, which this chemist pursues, is to treat the expressed juice or decoction of any plant with magnesia. This salifiable base forms insoluble salts with the acids, whether free or in a state of combination, which usually occur in vegetables. It consequently happens, in common cases, that the magnesia separates all the acids present in these liquids, and falls in the form of an insoluble powder. By this mode of proceeding, Peschier obtained liquids, having all the properties of a solution of carbonate of potash. This plan, however, will not succeed, in case the potash exists in the state of nitrate or of sulphate; as neither of these salts are decomposed by magnesia.*

The quantity of ashes and of potash furnished by several vegetables.

The following table indicates the quantity of ashes and of potash, yielded by 100 parts of several plants.

	Ashes.	Potash.
Fumitory	21·9	7·9
Wormwood	9·7	7·3
Common nettle	10·6	2·5
Beans with their stalks	—	2
Stalks of turkey wheat	8·8	1·75
Oak	1·3	0·15
Poplar	1·2	0·07
Fir	0·34	—

By the above table, it is perceived how small a quantity per cent. different plants yield of ashes and of potash. The fumitory yielded nearly 8 per cent. of potash, while the oak afforded only 1⅓ per cent. of ashes, and one and a half parts only in the 1000 of potash. By the above table also, it is seen, that the quantity of potash, which a plant contains, bears no certain ratio to the ashes which may be formed from it during combustion; and this arises from the circumstance, that the ashes contain variable quantities of other substances. Besides carbonate of potash, (the state in which potash is obtained by incineration from vegetables), there exists usually in them the following compounds; namely, sulphate of potash, sulphate of lime, phosphate of lime, and chloride of potassium.

2. Soda.

II. Soda may be obtained from almost all the plants which grow in the sea, or on the sea shore; and it is from different species of the salsola, a genus of plants of this kind, that a large proportion of the soda of commerce is extracted. Plants which yield soda, as a general rule, contain a larger proportional quantity of this alkaline base, than other

* Annals of Philosophy, xii. 336.

vegetables do of potash. Thus the salsola soda furnishes very nearly 20 per cent. of ashes, and nearly 2 per cent. of soda. Chap. I.

III. Lime is contained in larger or smaller quantity in every plant, which has hitherto been examined, except the salsola soda. It has already been stated, that it exists in them frequently combined with sulphuric or phosphoric acid. 3. Lime.

IV. Magnesia does not exist so generally in vegetables as lime. It has been discovered in several sea plants, especially the fuci. Vauquelin found that the salsola soda contains nearly 18 per cent. of magnesia. 4. Magnesia.

V. Alumina has been found in plants in but very small quantities. 5. Alumina.

VI. Silica exists in many plants, but particularly in grasses and equisetums. Sir H. Davy has ascertained, that it forms a part of the outermost bark of these plants. This chemist found, that the epidermis of the bonnet cane yielded 90 per cent. of silica; that of the bamboo 71 per cent.; that of the common reed 48 per cent. and that of the stalks of corn 6½ per cent. The concretions sometimes found in the bamboo cane, and called tabasheer, have been ascertained to be composed of silica, sometimes associated with potash. 6. Silica.

VII. Oxidized iron has been found in considerable quantities in the ashes of the salsola soda. It has also been detected in linen and cotton cloths. It has been discovered in many other vegetable substances. 7. Oxidized iron.

VIII. Oxidized manganese was first detected in vegetables by Scheele. It has been found by Proust in the ashes of the pine, of the vine, the green oak, and the fig-tree. 8. Oxidized manganese.

The following table gives the quantity in grains of the six last mentioned salifiable bases (the lime and magnesia in the state of carbonates), contained in thirty-two ounces of the seeds of wheat, of rye, of barley, of oats, and in the same quantity of rye straw, as ascertained by the experiments of Schrœder.

Substances present.	Wheat.	Rye.	Barley.	Oats.	Rye Straw.
Carbonate of lime.	12·6	13·4	24·8	33·75	46·2
Carbonate of magnesia.	13·4	14·2	25·3	33·9	28·2
Alumina.	·6	1·4	4·2	4·5	3·2
Silica.	13·2	15.6	66·7	144·2	152
Oxidized iron.	2·5	·9	3·8	4·5	2·4
Oxidized manganese.	5·0	3·2	6·7	6·95	6·8
	47·3	48·7	131·5	227·8	238·8

CHAPTER II.

OF THE ULTIMATE CONSTITUENTS OF VEGETABLES.

Ultimate constituents of vegetables.

The consideration of the proximate constituents of vegetables is now finished. But these constituents may be referred to certain ultimate constituents, or, to speak more correctly, to substances as yet undecompounded. It is the object of the present chapter to notice them.

The following statement gives a view of the whole of the ultimate constituents of vegetables, and the states of combination in which they occur.

SUPPORTERS.	1. OXYGEN.	In various states of combination.
	2. CHLORINE.	Combined with Potassium, Sodium and Magnesium, forming chlorides.
	3. IODINE.	Combined with Hydrogen, in the form of hydriodic acid.
INCOMBUSTIBLES.	1. AZOTE.	In various states of combination.
COMBUSTIBLES.	1. HYDROGEN.	In various states of combination.
	2. CARBON.	In various states of combination.
	3. PHOSPHORUS.	Combined with Oxygen, forming phosphoric acid.
	4. SULPHUR.	Combined with Oxygen, forming sulphuric acid.
	5. POTASSIUM.	Combined with Oxygen forming potash, and with Chlorine forming chloride of potassium.
	6. SODIUM.	Combined with Oxygen forming soda, and with Chlorine forming chloride of sodium (common salt.)
	7. CALCIUM.	Combined with Oxygen, forming lime.
	8. MAGNESIUM.	Combined with Oxygen forming magnesia, and with Chlorine forming chloride of magnesium.
	9. ALUMINUM.	Combined with Oxygen, forming alumina.
	10. SILICUM.	Combined with Oxygen, forming silica.
	11. IRON.	Combined with Oxygen, forming oxidized iron.
	12. MANGANESE.	Combined with Oxygen, forming oxidized manganese.

The great bulk of vegetables is composed of oxygen, hydrogen and carbon.

These ultimate constituents occur in very different quantities in plants. The great bulk of them is composed of one supporter, oxygen, and two combustibles, hydrogen and carbon. In some vegetable substances, azote is associated with the three substances already named; and where it is present, it occurs next in amount to them. The remaining ultimate constituents, comprising two supporters and ten combustibles, occur in comparatively very small quantities.

BOOK III.

ANIMAL CHEMISTRY.

PART II. BOOK III.

Animal chemistry treated of in five chapters.

THIS portion of the subject will be treated of in five chapters. Chapter I will embrace the consideration of the constituents of animals, as far as they have been discovered by the researches of chemists. Chapter II will have for its title the analysis of animal substances, and will give in detail the composition of the organized parts, and the products of the human body. In Chapter III, reflections will be entered into upon the chemical constitution of the human body. In Chapter IV, those animal functions which are elucidated by chemistry will be briefly noticed. In Chapter V, the chemical changes which take place in animals after death will be described.

CHAPTER I.

OF ANIMAL CONSTITUENTS.

Proximate constituents of animals enumerated.

THE proximate constituents of animals may be arranged under the following heads:

1. Gelatin.
2. Albumen.
3. Fibrin.
4. Colouring matter of the blood.
5. Mucus.
6. Osmazome.
7. Picromel.
8. Urea.
9. Saccharine matters.
10. Cantharidin.
11. Cochenilin.
12. Oils.
13. Resins.
14. Compound substances, already described in the first part of this work, as animal constituents.

All the substances, included in the above enumeration, except cantharidin, cochenilin and the resins, are constituents of the human body. They will be noticed in the order in which they have been named, in the following sections.

SECTION I.

OF GELATIN.

Gelatin exists in several animal substances.

1. GELATIN forms an essential constituent in bone, ligament, tendon, membrane, and in several other parts of animals. It exists in great abundance in the hide of the ox,

from which it may be extracted by the following process. Take a portion of the hide, and, after having separated the hair and other impurities, wash it with cold water, until this liquid ceases to abstract any thing. Then boil it in water for some time, and evaporate the decoction, until reduced to a small quantity. The concentrated decoction, upon cooling, assumes a solid form and a tremulous consistency, and is the same with the animal jelly, used sometimes as food. It is called by chemists gelatin. If the tremulous gelatin be evaporated to dryness by exposure to air, it becomes hard and semitransparent, and breaks with the glassy fracture. In this state, it is called dry gelatin, and is the same substance, which is so frequently employed in the arts under the name of glue.

Process for extracting it from the hide of the ox.

2. When perfectly pure, gelatin is colourless. It is destitute of taste or smell. In the dry form, it does not dissolve readily, but swells and forms a soft mass; but in the tremulous state, it is completely soluble, if mixed and shaken with water soon after it has gelatinized. It is soluble in hot water, and forms an opal-coloured solution. When made by dissolving one part of gelatin in one hundred parts of hot water, the solution assumes the tremulous form, upon cooling.

Properties of gelatin.

3. Dry gelatin undergoes no change by exposure to the atmosphere; but tremulous gelatin, or gelatin in solution, very soon undergoes the putrefactive process. When in a dry state, if it be exposed to heat, it first whitens and curls up like horn, then blackens, and is gradually converted into charcoal. Tremulous gelatin, under similar circumstances, first melts, and afterwards becomes black.

Effects of the stronger acids.

4. When nitric acid is digested upon gelatin, it is partly dissolved, and partly converted into oxalic and malic acids, and an oily matter which appears on the surface of the liquid. Hydrochloric (muriatic) acid dissolves it readily, and forms a brown-coloured acid solution, which gradually lets fall a white powder. With sulphuric acid, it forms a brown solution, which gradually deepens in colour.

5. Solutions of potash or soda dissolve gelatin readily. The compounds formed do not possess the properties of soap.

6. Gelatin is insoluble in alcohol; and when this liquid is added to a solution of gelatin, the latter becomes milky. When tannin is dropped into a solution of gelatin, it throws down a copious white precipitate, consisting of tannin and gelatin, which forms an elastic adhesive mass. This precipitate soon dries in the open air, whereby it becomes converted into a brittle, resinous-like substance, insoluble in water, capable of resisting the greater number of chemical

Forms a precipitate with tannin.

agents, incapable of putrefaction, and possessing, in short, all the properties of overtanned leather. It is on account of this property of tannin, that it is usually employed to detect the presence of gelatin in animal liquids. It must be borne in mind, however, that tannin throws down albumen also in the form of a white precipitate; and hence this substance is not a decisive test of gelatin. To prevent all fallacy in ascertaining the presence of gelatin, an animal liquid should be first tested by means of perchloride of mercury (corrosive sublimate), which will separate albumen, if any be present.

Tannin throws down albumen as well as gelatin.

Composition of gelatin.

7. According to an analysis by Gay-Lussac and Thenard, gelatin is composed of

Carbon	47·881
Oxygen	27·207
Hydrogen	7·914
Azote	16·998
	100·000

Glue, size and isinglass are different varieties of gelatin.

8. Gelatin, with some variety of properties, is used in the arts under the several names of glue, size and isinglass. The uses of glue are very well known. It is manufactured from the parings of hides, and from the hoofs and ears of horses, oxen and other domestic animals, by boiling them in water, and evaporating the solution formed to a proper consistency. Size is a purer kind of glue, manufactured from eel skins, parchment, some kinds of white leather, the skins of horses, cats, rabbits, &c. It is employed in the manufacture of paper, and in several other arts. Isinglass is very nearly pure gelatin. It is prepared, almost exclusively in Russia, from the air-bladders of different species of fish of the genus accipenser. This kind of gelatin is employed in clarifying spirituous liquors, in stiffening silk, and for other purposes.

SECTION II.

OF ALBUMEN.

Albumen, the peculiar substance, called the white of the egg.

1. The peculiar substance, found in the eggs of fowls, and called the *white* of the egg, is very nearly pure albumen.

2. Albumen, when exposed to heat, assumes the solid form, and is said to be coagulated. Coagulated albumen is very distinct in its properties from uncoagulated albumen, and will be noticed separately.

Properties of uncoagulated albumen.

3. Uncoagulated albumen is a glairy liquid, having very little taste and no smell. It is readily soluble in water; and the solution changes vegetable blues to green, in conse-

quence of the presence of soda. When exposed to the temperature of 165°, it is converted into coagulated albumen. The same effect is produced by acids or alcohol. When exposed to the air for spontaneous evaporation, or to a low heat, it is converted into a brittle, transparent substance, having some resemblance to glass, which may be again dissolved in water, so as to form a glairy liquid as at first. When uncoagulated albumen is diluted with a large quantity of water, for example, ten times its weight, it is no longer coagulable by heat; though acids are still capable of producing its coagulation. When diluted with a still larger quantity of water, even acids lose their coagulating power. The same is the case with dried uncoagulated albumen: when dissolved, in this state, in nine parts of water, it is completely coagulable by heat; but when dissolved in thirteen parts of water, an imperfect coagulation only takes place by the same means, and the liquid admits of being poured from one vessel to another.

Its coagulation by heat, not yet explained.

4. During coagulation, albumen neither gains nor loses any principle, nor alters in the least in its specific gravity. It, therefore, becomes a difficult point to ascertain upon what its coagulability depends. It is, however, most probable, that the coagulating cause gives a new play to chemical affinities, so that the constituents of the albumen assume new states of combination.

5. Uncoagulated albumen, unless dried, very soon undergoes putrefaction; and this the more readily, the more it is diluted. Its smell, during putrefaction, is like that of pus.

Perchloride of mercury, a good test for albumen.

6. Dr. Bostock has ascertained, that a saturated solution of perchloride of mercury (corrosive sublimate) is a most delicate test of the presence of albumen. A liquid, containing not more than $\frac{1}{1000}$th part of its weight of albumen, is rendered sensibly milky by the addition of a drop of this chloride. Tannin also has the property of precipitating albumen. It falls, in combination with the albumen, in the form of a very copious yellow precipitate, having the consistence of pitch, and which, when dried, becomes brittle and resembles overtanned leather. Tannin, however, is a much less delicate test of albumen than of gelatin.

Coagulated albumen described.

7. Coagulated albumen is a tough substance, having a pearl-white colour, and a sweetish, mucilaginous taste. It is insoluble in water, and is much less susceptible of putrefaction or decomposition than when in the uncoagulated state. When dried at a heat of 212°, it is converted into a hard, brittle, yellow substance, semitransparent like horn. From this dried state, it may be brought back to that of newly coagulated albumen, by digestion for several hours in water.

Converted into gelatin by the action of nitric acid.

8. Coagulated albumen, by being steeped in diluted nitric acid for some time, is converted, as Hatchett has ascertained, into a substance, soluble in water and possessing the distinguishing properties of gelatin.

9. Coagulated albumen is readily soluble in a boiling solution of potash; ammonia becomes disengaged, and an animal soap is formed.

Composition of albumen.

10. According to an analysis by Gay-Lussac and Thenard, albumen is composed of

Carbon	52·883
Oxygen	23·872
Hydrogen	7·540
Azote	15·705
	100·000

11. It deserves to be mentioned, that, besides these constituents, Berzelius considers sulphur, phosphorus, calcium and magnesium to be essential component parts in albumen. The first of them, sulphur, is a never-failing attendant upon albumen, wherever it may be found. This circumstance would seem to prove this combustible to be an essential constituent in it; but how far the same is true with regard to phosphorus, calcium, and magnesium remains yet to be satisfactorily shown.

SECTION III.

OF FIBRIN.

Fibrin, how obtained from blood.

1. If the clot, which forms in blood soon after it is drawn from an animal, be put into a linen cloth, and washed repeatedly with water, until it ceases to give colour or taste to this liquid, what remains behind will consist of fibrin. This substance was formerly called the fibrous part of the blood. It is found to exist abundantly in the muscular structure of animals, from which it may be obtained by repeated boilings in water.

Its properties.

2. Fibrin is a solid substance, having a white colour, which deepens upon drying, and no taste or smell. When newly extracted from blood, it is soft and elastic, and resembles vegetable gluten. That which is extracted from muscle is brittle, and possesses some degree of transparency. It is not altered by exposure to air, or speedily so by being kept under water. It is insoluble in cold water. In boiling water, it curls up; and, after the boiling has continued for some time, a kind of milky solution is formed, precipitable by infusion of nut-galls in white flocks, which do not cohere as those produced in a solution of gelatin do.

3. Both alcohol and ether dissolve fibrin, but not without altering its properties. When it is obtained again by evaporation from these solutions, it is in the state of a fatty mass, having a strong and unpleasant smell.

Dissolves in alcohol and ether with alteration.

4. In solutions of pure potash or soda, fibrin swells, and becomes transparent and gelatinous. At last a complete solution is effected, having a yellow colour with a shade of green. This solution has no analogy to soap, but the fibrin has undergone some alteration in its properties. It is precipitated by acids and by alcohol.

5. When exposed to heat, fibrin contracts suddenly, moves like a piece of horn, and exhales the odour of burning feathers. When the heat is increased to a certain temperature, it melts.

Effects of heat.

6. According to an analysis by Gay-Lussac and Thenard, fibrin is composed of

Composition.

Carbon	53·360
Oxygen	19·685
Hydrogen	7·021
Azote	19·934
	100·000

SECTION IV.

OF THE COLOURING MATTER OF THE BLOOD.

1. This peculiar animal substance may be obtained in the following manner: Mix one part of the clot of blood, as completely freed from serum as possible, with four parts of sulphuric acid, diluted with eight parts of water. Keep the mixture at the temperature of 158° for five or six hours, and then filter it while hot, washing the residue with four parts of hot water. Evaporate the liquid, thus obtained, to one-half, and then add ammonia, until the acid is almost, but not completely, saturated. A precipitate appears, which, after being washed and dried, is the colouring matter of the blood.

Colouring matter of blood, how obtained.

2. Leuenhoeck, by microscopical observations, ascertained the existence of globules of a red colour, floating in the blood; and his statements were confirmed by subsequent observers. The red globules were, accordingly, considered to be the colouring matter of the blood, but nothing was known of their chemical nature. In 1797, Dr. Wells published a paper, in which he attempted to prove, that the colouring matter of the blood is a peculiar animal subtance. This opinion, however, was not acceded to; as it

Account of its discovery.

appeared to be proved by Fourcroy and Vauquelin, that the red colour of the blood was owing to the presence of a subphosphate of iron. This continued to be the prevailing opinion, until Brande published his chemical researches on the blood in 1812; in which he proved experimentally, that the colouring matter of the blood is a peculiar animal substance. It appears, however, that the results of Brande had been anticipated by Berzelius, in a work published in 1808 in the Swedish language, but which was not known in England at the time Brande wrote.

Properties of the colouring matter.

3. The colouring matter of the blood is destitute of taste or smell. When dry, its colour is black. It is not soluble in cold water, but when suspended in this liquid, it has a wine-red colour. Boiling water produces the same effects upon it, as upon fibrin. It is soluble in all the acids, tried by Vauquelin and Brande. It dissolves in diluted nitric acid without any change in colour. Solutions of potash or soda dissolve it and form purple liquids. When exposed to heat, it neither alters its form nor colour; but gives out an animal odour, and yields carbonate of ammonia and a purple oil, the residue being a bulky charcoal. The great bulk of this animal constituent is considered to be composed of some modification of fibrin. When incinerated, it leaves $\frac{1}{80}$th of its weight of ashes, which are composed, according to Berzelius, of

Its ashes contain iron.

Oxidized iron	50·0
Subphosphate of iron	7·5
Phosphate of lime with traces of magnesia	6·0
Pure lime	20·0
Carbonic acid and loss	16·5
	100·0

4. Berzelius calculates, that the colouring matter of the blood contains about $\frac{1}{300}$th of its weight of oxidized iron. This chemist considers, that the substances, indicated in his analysis, do not exist in the colouring matter, but are formed during its incineration. He supposes the radicals only to be present; namely, iron, phosphorus, calcium, and magnesium.

SECTION V.

OF MUCUS.

Animal mucus differs from

1. ANIMAL mucus must not be confounded with the vegetable substance of the same name. The former, however, has several properties in common with the latter. Accord-

ing to Dr. Bostock, it may be obtained, by solution and filtration, from the white matter, formed by evaporating saliva. This chemist also obtained it, by macerating an oyster in water, and evaporating the liquid formed. When thus prepared, it has the following properties.

CHAP. I. Vegetable mucus.

2. It agrees with gum arabic in appearance, taste, solubility, and in the property which it possesses of forming with water an adhesive solution. After evaporation to dryness, it is transparent and inelastic, and resembles gum: it is now insoluble in water, but readily so in all the acids, even when much diluted. It is insoluble in alcohol or ether. It does not coagulate by heat, or gelatinize by evaporation. It is not precipitated by perchloride of mercury (corrosive sublimate), or the infusion of nut-galls; but subacetate of lead occasions a copious white precipitate.

Its properties.

SECTION VI.

OF OSMAZOME.*

1. THIS substance may be obtained by the following process: Macerate small fragments of beef, in water, for several hours, and repeat the maceration several times with fresh quantities of water. The liquid, thus obtained, holds, in solution, albumen, the salts of the beef, and osmazome. Separate the albumen by coagulating it by heat, and treat the residue, evaporated to the consistence of a syrup, with alcohol; this liquid takes up the osmazome, and leaves the salts behind.

Osmazome, how obtained.

2. This substance was first pointed out by Rouelle. The name, by which it is here distinguished, was applied to it by Thenard. Dr. Thomson thinks it not improbable, that it is fibrin, somewhat altered in its properties.

3. Osmazome is a brownish-yellow substance, having the taste and smell of broth. It is soluble both in water and alcohol. Its aqueous solution is precipitated by infusion of nut-galls, by nitrate of mercury, and by acetate and nitrate of lead.

Its properties.

SECTION VII.

OF PICROMEL.†

1. THENARD has given this name to the peculiar substance which characterizes bile. It may be obtained by the

Picromel, how obtained.

* From οσμη smell, and ζωμος broth. † From πικρος bitter, and μελι honey.

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following process: Mix fresh bile with sulphuric acid, diluted with three or four times its weight of water. The yellow precipitate, which thereby appears, must be allowed to subside, and then separated. Next heat the mixture gently for some hours, and then decant the liquid part: a green matter will remain, formerly called resin of bile, but at present ascertained to be a compound of the peculiar substance, under notice in the present section, and sulphuric acid. Digest this matter with carbonate of barytes and water. An insoluble sulphate of barytes will be formed; and the picromel, liberated from combination, will be found dissolved in the water. It may be obtained from its aqueous solution by evaporation to dryness.

Its properties.

2. Picromel resembles inspissated bile very exactly. It has a yellowish-green colour, and an intensely bitter taste, which leaves an impression of sweetness. It is soluble in water and alcohol. It dissolves in ether also, but not without alteration in its properties. It is not precipitated by the infusion of nut-galls, but is thrown down by nitrate of mercury, subacetate of lead, and the salts of oxidized iron.

SECTION VIII.

OF UREA.

Urea, how obtained.

1. Urea may be obtained by the following process: Evaporate any quantity of human urine, by a gentle heat, to the consistence of a syrup, and set it aside to cool: it will be found concreted into a crystalline mass. Pour upon this mass, at several intervals, four times its weight of alcohol, and apply a gentle heat: this menstruum will leave nothing, but some saline substances. Distil the alcoholic solution, thus obtained, in a retort, until it assumes the consistence of syrup; at which time, the whole of the alcohol will have been driven over. The syrupy mass, upon cooling, takes the form of crystals. These crystals consist of urea.

2. This substance was first examined, in 1773, by Rouelle, junior, under the name of the saponaceous extract of urine. In 1799, a full investigation of its nature was made by Fourcroy and Vauquelin, by whom the name urea was given.

Its properties.

3. Urea is a crystallized substance, usually of a yellowish-white colour; but, when pure, semitransparent and white. It has a fetid smell, somewhat similar to that of garlic. Its taste is acrid, resembling that of the ammoniacal salts. It is viscid and difficult to cut, and has somewhat the appear-

stance of thick honey. By exposure to air, it attracts moisture, and is soon converted into a thick brown liquid. It is very soluble in water, and during its solution a considerable degree of cold is produced. It dissolves also readily in alcohol, but not in so large a proportion as in water. The aqueous solution, when left to itself, gradually putrefies, and the urea appears to be converted into ammonia and acetic acid. When distilled, it exhales a very fetid alliaceous odour, and yields carbonate of ammonia, bihydroguret of carbon, charcoal, benzoic acid, chloride of sodium, and hydrochlorate of ammonia;* but the three last products are considered by Fourcroy and Vauquelin to be foreign substances.

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4. When nitric acid is poured upon crystallized urea, a violent effervescence takes place, large quantities of deutoxide of azote, carbonic acid, and azote are evolved, and the mixture assumes a dark red colour. After the action is over, there remains, together with some drops of reddish liquid, a white concrete matter, which, when heated, detonates like nitrate of ammonia. When, however, nitric acid is dropped into a concentrated solution of urea in water, there immediately fall a number of bright pearl-coloured crystals, which are found to consist of nitric acid and urea. No other acid tried produces this singular effect upon urea. When a solution of urea is mixed with one-fourth of its weight of sulphuric acid, no effervescence ensues; but when heat is applied, there appears, on the surface of the liquid, a quantity of oil, which concretes upon cooling. The other products of the action of this acid are acetic acid and ammonia. Hydrochloric acid dissolves urea without alteration.

Action of nitric acid upon it; of sulphuric acid; and of hydrochloric acid.

5. Urea dissolves readily in solutions of potash or of soda, and ammonia becomes evolved. The same evolution is produced by barytes, lime, or even magnesia. The ammonia is derived from hydrochlorate of ammonia, with which urea is constantly mixed.

6. According to an analysis by Dr. Prout, urea is composed of

Its composition.

Azote	14—one atom.
Carbon	6—one atom.
Hydrogen	2—two atoms.
Oxygen	8—one atom.†
	30

* It may be worth while to remark, that the products of the distillation of urea are a good deal similar to those furnished by uric acid, under like circumstances.

† This analysis is taken from an abridgment of Dr. Prout's paper on the proximate principles of the urine. Annals of Philosophy, xi. 352.

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It consequently appears, that urea differs from uric acid, in containing an atom less of carbon, and an atom more of hydrogen; and from purpuric acid, in containing an atom less of both carbon and oxygen.

SECTION IX.

OF SACCHARINE MATTER.

Principal kinds of animal saccharine matter are

THREE kinds of saccharine matter of animal origin may be enumerated; namely, sugar of milk, honey, and the sugar of diabetic urine. These substances will be briefly noticed in the order in which they have been named.

1. Sugar of milk;

I. Sugar of milk may be obtained by the following process: Evaporate fresh whey to the consistence of honey, and, after it has concreted into a solid mass by cooling, dissolve it in cold water, and clarify the solution by means of the white of eggs: then filter it, and evaporate it to the consistence of a syrup. This syrup, upon cooling, deposites a number of brilliant white crystals. These crystals consist of the substance in question.

Sugar of milk is in the form of semi-transparent crystals, having a whitish colour and a sweetish taste, but no smell. Its specific gravity is 1·5. It is soluble in five times its weight of cold water, and in two and a half times its weight of boiling water. It is insoluble both in alcohol and ether. When exposed to heat, it emits the smell of burning sugar. When distilled, it yields very nearly the same products as sugar. When treated by nitric acid, it is converted into saclactic acid. According to Gay-Lussac and Thenard, it is composed of

Oxygen	53·834
Carbon	38·825
Hydrogen	7·341
	100·000

2. Honey; and

II. Honey is, perhaps, rather of vegetable than of animal origin. It has a yellowish colour, a soft and grained consistence, a saccharine taste, and an aromatic smell. It is converted into oxalic acid by the action of nitric acid. It is very soluble in water, with which it forms a syrup.

3. Sugar of diabetic urine.

III. The sugar, which may be extracted from the urine of persons labouring under diabetes, possesses properties analogous to those of common sugar. When treated with nitric acid, it yields, like common sugar, a portion of oxalic acid. No saclactic acid is formed.

SECTION X.

OF CANTHARIDIN.

1. Dr. Thomson gives this name to the substance, discovered in 1810 by Robiquet, in which the vesicating property of cantharides resides. It is obtained from the Spanish flies by digesting them, successively, in water, alcohol, and sulphuric ether. It is in the form of shining crystalline plates, insoluble in water and in cold alcohol, but soluble in boiling alcohol, which lets it fall upon cooling. It is soluble also in ether and in the oils. When applied to the skin, it acts with great energy as a vesicatory.

Cantharidin, the vesicating principle of cantharides.

SECTION XI.

OF COCHENILIN.

1. Cocheneal is well known as an insect, which inhabits different species of cactus, and is propagated in Mexico and in some other countries, for the sake of the beautiful dye, which it affords. It constitutes the scarlet dye of cloth. Dr. John has succeeded in separating the colouring matter of this insect, to which he has given the name of cochenilin. It has a fine carmine-red colour. It is permanent in a dry air, but becomes glutinous in a moist one. It is soluble in acids, and in pure potash or soda.

Cochenilin, the colouring matter of cocheneal.

SECTION XII.

OF OILS.

1. Oils are noticed in this place, in order that the enumeration of animal substances may be complete. The reader will no doubt recollect, that the oils in general were treated of pretty fully in a previous part of this work. It would, therefore, be a needless repetition to enter upon their consideration in this place. It may not, however, be without its use to give some account of the animal oil of Dippel.

Oil enters largely into animal bodies.

2. This oil is obtained by distilling the gelatinous and albuminous parts of animals. The product of the first distillation is redistilled, mixed with water; and the oil which first comes over is the animal oil in question. It is a colourless and transparent liquid, possessing a strong and rather aromatic smell. It is nearly as light, and quite as volatile

as ether. It is partially soluble in water. It changes vegetable blues to green, owing, as is supposed, to the presence of ammonia. It dissolves in acids, and forms a kind of imperfect soap. It was formerly held in high estimation as a remedy for fevers, but it is a long time since it has lost its celebrity.

SECTION XIII.

OF ANIMAL RESINS.

Principal animal resins are

SEVERAL substances of an animal origin, which partake of the nature of resins, have been classed together under the name of animal resins. The principal of them will be briefly noticed in the following paragraphs.

1. Ambergris:

I. *Ambergris.*—This substance is found floating in the sea, near the coasts of tropical countries, especially of India, Africa, and Brazil. It has been supposed to be of vegetable origin; but it is now generally believed, that it is a concretion formed in the stomach and intestines of the physeter macrocephalus, or spermaceti whale. It is a soft substance of an ash-grey colour, with brownish, yellow, and white streaks, and of a specific gravity, varying from 0·78 to 0·92. It has an agreeable smell, and an insipid taste. It is composed principally of resin, and a matter with properties intermediate to those of fat and wax, mixed with benzoic acid and charcoal.

2. Bee-glue:

II. *Propolis* or *Bee-glue.*—This is the substance, which bees employ to cover the bottom of a hive, when newly placed in it. It is not altogether certain, that it is an animal substance. It is at first soft and ductile, but, by exposure to air, becomes hard. In masses it appears black, but in thin pieces, semi-transparent. It has no taste, but possesses an aromatic odour. It was ascertained by Vauquelin to be composed principally of resin and wax.

3. Civet:

III. *Civet.*—This substance is obtained from the inguinal region of the civet cat. It is a yellow substance of the consistence of butter. It is employed as a perfume only, for which purpose it requires that its odour, which is very strong, should be greatly diluted. It has not been analyzed by any chemist; but it may, without impropriety, be classed among the animal resins, until its nature is better known.

4. Castor: and

IV. *Castor.*—This substance is contained in two bags, a large and a small one, situated in the inguinal regions of the beaver. It is the larger bag on each side, which contains the true castor; the smaller one contains a substance resembling it, but much less esteemed. Castor has a yellow

colour, and, when newly taken from the animal, is nearly liquid. By exposure to air, it hardens, becomes dark-coloured, and assumes the appearance of a resin. Its taste is acrid and bitter, and its smell strong and aromatic. When used as a medicine, it acts as a stimulating antispasmodic, encreasing the heat of the body in a slight degree only.

5. Musk.

V. *Musk.*—This is a secretion, which is deposited in a kind of bag, situated in the umbilical region of the moschus moschiferus, or musk deer, an animal, which inhabits the more elevated regions of Asia, particularly the mountains which divide Thibet from China. It has a brownish-red colour, a bitter taste, an intensely strong and aromatic smell, and an unctuous feel. It is partially soluble in water, to which it imparts its odour; and also in alcohol, but this liquid retains none of the odour. It is dissolved, and rendered inodorous, by sulphuric or nitric acid. As a medicine, it acts as a very powerful stimulating antispasmodic.

SECTION XIV.

OF COMPOUND SUBSTANCES, DESCRIBED IN THE FIRST PART OF THIS WORK, AS ANIMAL CONSTITUENTS.

Compound substances already described, as animal constituents, are either 1. Chlorides:

THESE substances are either I. Chlorides; II. Acids; III. Salifiable Bases.

I. *Chlorides.*—In a large proportion of the liquids of the human body, and in some of the solids, chloride of sodium (common salt) is detected upon analysis. Chloride of potassium (muriate of potash) is present also in several animal substances.

2. Acids: or

II. *Acids.*—There have been discovered, in the analysis of the human body, the following acids; namely, the hydrochloric, sulphuric, carbonic, phosphoric, uric, oxalic, and lactic. The four first named are acids of two constituents; the sixth and seventh are composed of oxygen, hydrogen, and carbon, and the fifth, of the same ingredients, with the addition of azote. The uric and lactic acids are peculiar to animal matter. Hydrochloric acid is found in urine combined with ammonia. Sulphuric acid is a constant ingredient in human urine. Carbonic acid is a constituent in several parts of the human body. Phosphoric acid is the most abundant acid in man, as well as in other animals. Combined with lime, it constitutes the basis of bone. It constitutes also a component part of almost all the solids and liquids of the body. The uric acid is found exclusively in urine and urinary calculi. Oxalic acid has been found as a

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constituent in a species of urinary calculi, to be noticed hereafter. Besides these acids, which have been detected in the different parts of the human system, the benzoic acid has been found abundantly in the urine of cows, and the formic, acetic and malic acids have been extracted from the red ant, the first as peculiar to this insect.

3. Salifiable Bases.

III. *Salifiable Bases.*—The salifiable bases, found in the constitution of the human body, are ammonia, potash, soda, lime, magnesia, silica, oxidized iron, and oxidized manganese. Ammonia exists ready formed in human urine, and is produced abundantly by the putrefaction of animal substances. Potash exists in a few of the liquids of the body. Soda is present in almost all parts of the human structure. Lime exists abundantly in bones, combined with phosphoric acid. Magnesia has been detected in human urine, combined with phosphoric acid and ammonia. Silica has been detected in small quantities in hair. Oxidized iron has been found as a constituent of blood, and oxidized manganese as a constituent of hair.

CHAPTER II.

ANALYSIS OF THE SUBSTANCES COMPOSING THE HUMAN BODY.

Animal substances will be considered under the heads of 1. Organized parts. 2. Healthy products. 3. Morbid products.

All the substances, composing the human body, may be arranged under the general heads of 1. Organized parts, 2. Products of vital action. But the products of vital action may be either natural or healthy, or morbid; and it will be convenient to describe them separately, according as they may be the one or the other. Animal substances, therefore, will be noticed under the following heads:

I. Organized Parts.
II. Healthy Products.
III. Morbid Products.

I. ORGANIZED PARTS.

Organized parts, enumerated.

The substances included under this head are,

1. Bone.
2. Nail.
3. Muscle.
4. Skin.
5. Membrane, Tendon, Ligament & Cartilage.
6. Gland.
7. Brain and Nerve.
8. Marrow.
9. Hair.

They will be noticed, in the order in which they have been enumerated, in the following sections.

SECTION I.

OF BONE.

1. THE external appearances of bone are too well known to require description. Its internal structure is more or less cellular. Its weight is somewhat various, but is at least twice that of water. Its component parts by chemical analysis are chiefly four; namely, an incombustible part, fat, gelatin and albumen.

Bone contains four proximate constituents.

2. The incombustible part may be obtained by burning the bone to whiteness, or by steeping it, for a sufficient time, in a diluted acid. In the first case, the fat, gelatin and albumen are burnt off; in the second, the incombustible part dissolves in the acid liquor, from which it may be thrown down by proper precipitants.

1. An incombustible part.

3. The fatty part may be obtained from bone by boiling it, reduced to small pieces, in water. The fat will be found swimming on the surface.

2. Fatty matter.

4. The gelatin is obtained by boiling the bone, for a sufficient time, in water, by which means it is dissolved. If the solution be sufficiently concentrated, as it cools the gelatin assumes the solid form. It is this constituent which renders bone fit for the formation of portable soup, the basis of which is gelatin. Bone contains about $\frac{1}{16}$th part of its weight of gelatin.

3. Gelatin.

5. When bone is deprived by boiling of its fatty and gelatinous parts, and of its incombustible part by the action of a diluted acid; a soft, white, elastic substance remains, which has the figure of the original bone, and which appears to be the same substance, found tipping the ends of bones, and called by anatomists cartilage. Chemically examined, it is found to possess all the properties of coagulated albumen.

4. An albuminous part: or the cartilage of bone.

6. The incombustible part of human bone, according to Berzelius, is composed of

Principal constituent of the incombustible part of human bone is phosphate of lime.

Phosphate of lime	81·9
Hydrofluate (fluate) of lime	3·0
Lime	10·0
Phosphate of magnesia	1·1
Soda	2·0
Carbonic acid	2·0
	100·0

7. The substances given in this analysis, together with gelatin, albumen and a portion of fat, which three constituents form thirty-seven parts in every hundred of fresh bone, make up the proximate constituents of human bone.

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They may be all referred to the following ultimate constituents; namely, oxygen, fluorine, azote, hydrogen, carbon, phosphorus, sodium, calcium, and magnesium. Of these, oxygen, carbon, phosphorus and calcium are the principal ingredients.

Teeth are bone, covered with a peculiar substance, called enamel.

8. Teeth are composed of bone, which is somewhat different from common bone. That portion of them, which protrudes beyond the gum, is covered with a peculiar hard matter, denominated enamel. Enamel is destitute of albuminous and gelatinous parts. When subjected to the action of diluted acids, it is totally dissolved. According to Pepys, one hundred parts of enamel are composed of

Phosphate of lime	78
Carbonate of lime	6
Loss and water	16
	100

Enamel contains hydrofluate of lime.

9. Berzelius has detected about three per cent. of hydrofluate (fluate) of lime in recent teeth, as well as in bone. Teeth differ from common bone, in containing more phosphate of lime and less cartilaginous albumen.

Bone of inferior animals, chemically the same as human bone.

10. The bones of the inferior animals agree in composition with those of man. Ox bone yielded to Berzelius, upon analysis, all the constituents of human bone, with the additional one, in small proportion, of chloride of sodium (common salt.) Phosphate of magnesia exists in the bones of inferior animals in larger proportion than in human bone.

SECTION II.

OF NAIL.

Nail is a kind of coagulated albumen.

1. The human nail is the well known covering of the ends of the fingers and toes. This substance has been found by Hatchett to be chiefly composed of a membranous substance, which has the properties of coagulated albumen. It appears to contain also a small quantity of phosphate of lime.

2. The horns and hoofs of inferior animals are the same in chemical nature with the human nail; except, indeed, the horn of the buck and hart, which agrees exactly in properties with bone, and which, therefore, may be considered as improperly denominated horn. Tortoise-shell approaches very nearly to nail in its chemical nature.

SECTION III.

OF MUSCLE.

Muscle described.

1. Muscle is the substance, which, in common language, is called flesh. It is composed of a number of fibres or

threads, generally of a reddish colour. It is not easy to separate the muscular part, properly so called, from other substances, with which it is mixed. These are a portion of fat, a quantity of blood which pervades its whole substance, and cellular membrane which envelopes each fibre.

Analysis of muscle, how conducted.

2. When muscle is cut into small pieces and washed repeatedly with water, it is converted into a white, fibrous substance, having the characteristic properties of fibrin. The water, obtained from it, appears as if a portion of blood had been mixed with it; and, when heated, flakes of albumen, combined with the colouring matter of the blood, appear on its surface, and some fibrin precipitates. After being sufficiently concentrated, the whole gelatinizes. When in this state, if it be evaporated to dryness and treated with alcohol, a peculiar matter is taken up, while the gelatin and some ammonio-phosphate of soda remain behind. This matter had been considered to be a kind of extractive by Thouvenel; but Berzelius appears to have proved it to consist of lactic acid and lactate of soda. If muscle, after being treated with cold water, be boiled, it yields an additional portion of the substances already mentioned.

Its constituents.

3. Hence it would appear, that muscle is composed of fibrin, to which it owes its form and fibrous texture, united with albumen mixed with the colouring matter of the blood, gelatin, extractive, and ammonio-phosphate of soda.

Its composition, according to Berzelius.

4. Berzelius gives the following result of an analysis of muscle:

I. Solid matters.		
Fibrin, vessels and nerves	15·8	
Cellular matter dissolved by boiling	1·9	
		17.7
II. Liquid bodies.		
Chloride of sodium (muriate of soda), and lactate of soda	1·80	
Albumen and colouring matter of the blood	2·20	
Phosphate of soda	0·90	
Extractive	0·15	
Albumen, holding in solution phosphate of lime	0·08	
Water and loss	77·17	
		82·30
		100·00

5. Berzelius's analysis of muscle differs, in many respects, from that deduced from the action of water and alcohol

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upon the same substance. It agrees with this analysis, in giving fibrin, albumen and colouring matter, and phosphate of soda; while the lactate of soda of Berzelius's analysis may be taken as equivalent to the extractive of the other. On the other hand, it disagrees in giving chloride of sodium (muriate of soda), extractive and phosphate of lime as additional constituents, and in omitting gelatin.

Muscles of animals, different in sensible qualities from one another.

6. The account, here given, of the chemical constitution of muscle is to be considered as deduced from the examination of the muscular flesh of the ox. Although the muscular fibres of different animals differ very much in colour, and in taste when used as articles of food; yet there is no reason to suppose, that they would afford any chemical differences by analysis, unless, indeed, in the proportions of their constituents. It is for these reasons, that the above account of the muscle of the ox will apply with sufficient accuracy to the muscular parts of man.

Ultimate constituents of muscle enumerated.

7. From the analysis of Berzelius, just given, it would appear, that the ultimate constituents of muscle are oxygen, chlorine, azote, hydrogen, carbon, phosphorus, sodium, and calcium. Of these, oxygen, azote, hydrogen and carbon occur in much the largest proportion. The remaining substances occur in small proportion, and may, perhaps, be considered as accidental constituents. In the above enumeration, the ultimate constituents of the colouring matter of the blood are excluded, as belonging to a foreign ingredient.

SECTION IV.

OF THE SKIN.

The skin, composed of cuticle, true skin, and mucous network.

1. The human skin is composed of three laminæ; the cuticle or epidermis, the cutis vera or true skin, and a pulpy lamina between these, called the rete mucosum, or mucous network.

1. Cuticle.

2. The cuticle or epidermis is the exterior lamina of the skin, and is that portion of it, which is raised in blisters. It is easily separated from the true skin by maceration in hot water. It is thin and semi-transparent, and possesses a very great degree of elasticity. It is totally insoluble in water or in alcohol, but dissolves in solutions of pure potash or soda, and of lime; but slowly in solutions of the latter substance. It is not acted upon sensibly by sulphuric or hydrochloric acid; but nitric acid causes it to lose its elasticity and fall to pieces. This latter acid has the property of tinging the living cuticle of an indelible yellow colour. The

same effect is produced upon the dead cuticle by the action of this acid, but it requires a much longer time. The cuticle, when thus tinged, has its colour changed to a deep orange by the action of ammonia. The same effect is produced upon coagulated albumen under similar circumstances. From this fact, and from the effects of reagents upon cuticle, as above detailed, there is every reason to believe that this animal substance consists entirely of coagulated albumen.

It is a kind of coagulated albumen.

3. The true skin is an elastic, dense and strong membrane, composed of a great number of fibres, interwoven in an intricate manner. When macerated for several hours in water, the blood and other extraneous substances are removed, and the cutis remains, still preserving its fibrous texture. When boiled for a long time in water, it dissolves completely into a viscous liquid, which, upon evaporation, yields gelatin. Hence it would appear, that the cutis of man is composed of gelatin, modified in its nature, so as to enable it, by the compactness of its texture, to resist the action of water, except under particular circumstances.

2. True skin.

It consists of modified gelatin.

4. The cutis vera constitutes the part of the hide of inferior animals, which is susceptible of conversion into leather; and it is its gelatinous nature which fits it for this purpose. The hide is treated with lime, which destroys the cuticle and the hair; and the cutis, which remains, is then steeped in an infusion of oak bark, whereby it combines with tannin, and becomes leather.

True skin of man corresponds with the hide of inferior animals.

5. The rete mucosum has never been subjected to chemical analysis. It is known, however, that it gives rise to the difference in colour of the skin, occurring in different varieties of the human race. The true skin, in all nations, is the same both in colour and in texture; so also is the cuticle. On the other hand, the rete mucosum is black in the negro, yellow or tawny in many of the Asiatics, and yellowish-red in the aborigines of America; and, by being seen through the transparent cuticle, gives rise to the variety of colour in the skin of the human species. The black colour of the rete mucosum is destroyed by the action of chlorine, as Dr. Beddoes first proved by experiment, on the finger of a negro.

3. Mucous network gives rise to the difference of colour in the human race.

SECTION V.

OF MEMBRANE, TENDON, LIGAMENT, AND CARTILAGE.

None of these substances have been subjected to very careful analysis; so that a very slight notice of them will complete this section.

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1. Membrane consists of gelatin.

I. Membrane is a thin, transparent covering, with which different parts of the body are enveloped. The dura and pia mater, the pleura, peritoneum, and periosteum are all examples of membrane. It is susceptible of being tanned and converted into leather. When boiled a long time in water, it dissolves almost entirely, and the liquid formed is found to be a solution of glue. When burnt, it leaves scarcely any residuum. There can be no doubt, that membrane consists almost entirely of gelatin.

2. Tendon consists entirely of gelatin.

II. Tendons are too well known to require description. In common language, they are called sinews. When boiled a sufficient time with water, they are completely dissolved, and converted into gelatin.

3. Ligament is modified coagulated albumen, containing a portion of gelatin.

III. Ligament, the substance which binds the bones together, differs somewhat in chemical nature from the substances just described. When boiled, it yields a portion of gelatin; but, so far from dissolving entirely, it retains its form and even its strength. It is not unlikely that the part, which is insoluble after long boiling, is coagulated albumen, somewhat modified.

Cartilage is coagulated albumen, containing a little gelatin.

IV. Cartilage differs essentially from both membrane, tendon and ligament. It appears to yield a portion of gelatin by boiling; but the great mass of it is composed of a substance, insoluble in hot water, and analogous in its nature to coagulated albumen.

SECTION VI.

OF GLAND.

Gland is a very heterogeneous substance.

1. Glands are very complex bodies, made up of several distinct parts. The great mass of them is composed of blood-vessels. These vessels are held together by a kind of cellular texture, which, together with the blood pervading them, and the excretory vessels of those performing secretions, may be considered as comprising their whole substance. There is very little doubt, that they consist almost entirely of gelatin.

SECTION VII.

OF BRAIN AND NERVE.

Brain described.

1. Brain is a soft substance, possessing a soapy feel. Its specific gravity exceeds that of water. When kept in close vessels, it has very little tendency to undergo putre-

faction. Under such circumstances, it has remained a whole year without experiencing hardly any change. But when exposed to the open air at the temperature of 60°, in a few days it becomes green, exhales a very fetid odour, and gives out abundance of ammonia.

2. Cold water does not dissolve brain; but when triturated with this substance, a kind of emulsion is formed, which partly coagulates by heat, or by the action of acids or of alcohol. The part which coagulates is found to be albumen.

Effects of sulphuric acid upon it;

3. When brain is triturated with diluted sulphuric acid, with the exception of its albuminous part, it is totally dissolved. This solution, by evaporation, deposites crystals of sulphate of ammonia; and when this operation is continued to dryness, a black mass is obtained, which is partly soluble in water. The insoluble portion is charcoal; while the soluble portion is found to consist of the sulphates of ammonia and of lime, phosphoric acid, and the phosphates of soda and of ammonia. The sulphuric acid of the sulphates of ammonia and of lime is derived from the solvent; so that it would appear, that the salts contained in brain are the phosphates of lime, of soda, and of ammonia. Traces of sulphate of lime, however, are detected. All these salts, taken together, do not amount to more than $\frac{1}{300}$th part of the weight of brain.

and of nitric acid.

4. Nitric acid also dissolves the whole of brain, except the albuminous part. When the solution is concentrated by heat, carbonic acid gas and deutoxide of azote (nitrous gas) are given out, and afterwards a large quantity of ammonia is disengaged. There remains a bulky charcoal, mixed with a quantity of oxalic acid.

Its composition according to Vauquelin.

5. According to an analysis performed by Vauquelin, 100 parts of brain are composed of

Water	80·00
White fatty matter	4·53
Reddish fatty matter	0·70
Albumen	7·00
Osmazome	1·12
Phosphorus,	1·50
Acids, salts and sulphur	5.15
	100·00

6. Supposing the salts of Vauquelin's analysis to be the same as those just stated to exist in brain, then the ultimate constituents of this substance would be oxygen, azote, hydrogen, carbon, phosphorus, sulphur, sodium and calcium.

7. Anatomists have ascertained, that the nerves are composed of small fibres, consisting of a substance analogous to

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brain, and invested by a membrane, which appears to be derived from this organ. Vauquelin has found them to possess the same chemical nature as brain. The same is true with regard to the medulla oblongata and medulla spinalis.

Nerves, the same in chemical nature as brain.

SECTION VIII.

OF MARROW.

Marrow of the ox, not different from human marrow.

1. In the cavities of the long bones, there is found a peculiar substance of a fatty nature, which is denominated marrow. Berzelius has examined, in detail, the chemical properties of this substance, as it exists in the thigh bone of the ox. As it is not probable, that the marrow of human bones differs essentially from ox marrow, it may not be without its use to give the result of this examination.

Its analysis, how conducted.

2. Cold water, when digested upon ox marrow, takes up about $\frac{1}{100}$th part of this substance, which is ascertained to consist of coagulated albumen mixed with phosphate of lime and of iron, gelatin, and the peculiar extractive of Thouvenel. Boiling water causes it to melt and swim on its surface, and dissolves a part of it, which is found to consist chiefly of extractive, gelatin, and a peculiar matter, approaching, in properties, to coagulated albumen.

3. If marrow, after having been thus subjected to the action of hot and cold water, be melted and passed through a cloth, a portion remains on the cloth consisting of blood-vessels &c. It may now be considered as being in a state of purity.

Pure marrow described.

4. Pure marrow, thus obtained, is a soft substance, having a bluish-white colour, and rather sweetish taste. It melts when heated to the temperature of 113°. When distilled, it yields a liquid and a solid oil, water, carbonic acid gas and bihydroguret of carbon, and there remains a dark brown and brilliant charry matter, amounting to $\frac{1}{500}$th part of the marrow employed.

5. Berzelius states the constituents of 100 parts of ox marrow as follows:

Pure marrow	96
Skins and blood-vessels	1
Albumen, Gelatin, Extractive, Peculiar matter, Water	3
	100

6. From this statement, it appears, that marrow, as it is found in bone, is composed almost entirely of a peculiar fixed oil, to which Berzelius gives the name of pure marrow. All the component parts of marrow, exclusive of the phosphates of lime and of iron, may be referred to oxygen, azote, hydrogen or carbon as ultimate constituents.

SECTION IX.

OF HAIR.

Analysis of hair, how conducted by Vauquelin.

1. Vauquelin has published a minute analysis of human hair. By means of a Papin's digester, this chemist was enabled to dissolve this animal substance, which, at the boiling temperature, is insoluble in water. The solution contains a kind of oil, which may be separated by the filter.

2. The filtered solution, when treated with an infusion of nut-galls, lets fall a copious precipitate, which Vauquelin considers to be inspissated mucus, but which is considered by Hatchett, with more probability, as some modification of coagulated albumen. When silver is exposed to its action, it is blackened, which indicates the presence of sulphur. When very much concentrated by evaporation, it does not gelatinize. This would appear to show the absence of gelatin, but Achard and Hatchett have proved by experiment, that hair contains a portion of gelatin, to which it owes its suppleness and toughness.

3. When alcohol is digested upon black hair, it separates from it two kinds of oil; one of which falls in the form of white shining scales, as the alcohol cools, while the other, which is greyish-green, is obtained by evaporation.

4. When hair is incinerated, the ashes amount to not more than 1¼ parts in the 100. Vauquelin found these ashes to be composed of iron and manganese, phosphate, sulphate and carbonate of lime, chloride of sodium (muriate of soda), and a considerable quantity of silica. The ashes of red or white hair contain less iron and manganese than those obtained from other varieties; but they have magnesia as an ingredient, not found in the ashes of hair of other colours.

5. From these various data, furnished by the researches of Vauquelin and Hatchett, it would appear, that human hair is composed of the following substances:

Its constituents.

Coagulated albumen, somewhat modified.
Sulphur.
Gelatin.
Two kinds of oil.

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Iron and manganese.
Phosphate, sulphate, and carbonate of lime.
Chloride of sodium (muriate of soda.)
Silica.

6. From the above statement it follows, that the ultimate constituents of hair are oxygen, chlorine, azote, hydrogen, carbon, phosphorus, sulphur, sodium, calcium, silicum, iron, and manganese.

II. HEALTHY PRODUCTS.

Healthy products enumerated.

The healthy products of the vital action of the human body are nearly all secretions. They will be arranged as follows:

a. Products of the digestive function.—These are Chyle, Blood, and Feces.

All the remaining healthy products are secretions, and will be called by that name in giving the remaining groups of the arrangement.

b. Secretions subservient to the digestive function.—These are Saliva, Gastric Secretion, Pancreatic Secretion, and Bile.

c. Secretions subservient to the organs of sense.—These are Tears, Mucus of the nose, and Cerumen of the ear.

d. Secretions contained in circumscribed cavities.—These are Humours of the eye, Liquor of the pericardium, and Sinovia.

e. Secretions of an excrementitious nature.—These are Urine, and Sweat.

f. Secretions dependent upon sexual organization.—These are Semen, Milk, and Liquor of the amnios.

The healthy products will be noticed, in the order in which they have been named, in the following sections.

a. Products of the Digestive Function.

The products of the digestive function are Chyle, Blood, and Feces.

SECTION I.

OF CHYLE.

Chyle is taken up

1. Chyle is the liquid taken up from the food in the intestines, after the latter has undergone certain changes in the

stomach. Alimentary matter, thus fitted to yield chyle, is called chyme; and the vessels, which separate the chyle from it, are called lacteals. These vessels unite together and form one trunk, called the thoracic duct, which communicates with the blood-vessels. Chyle is, therefore, a product of digestion, which passes into the blood, in order to supply the waste, which this important liquid is constantly suffering in the circulation.

CHAP. II. from the alimentary mass, and discharged into the blood-vessels.

2. It is only within a few years, that the chemical nature of chyle has been investigated. The chyle of the horse was examined experimentally, in 1811, by Emmert, and, in 1812, by Vauquelin; in which year also, Brande examined the nature of this liquid. In 1815, Marcet made a comparative examination of the chyle of animals, according as they live upon vegetable or animal food.

3. Chyle, examined from the thoracic duct about five hours after food has been taken, is a white, opaque, liquid, without smell, and having a slightly acid taste, mixed with a perceptible sweetness. In about ten minutes after it is drawn, it coagulates into a stiff jelly. After remaining twenty-four hours, it separates into two distinct parts; a firm, contracted coagulum, and a colourless liquid.

Chyle described.

It coagulates.

4. Vauquelin considers the coagulum, as a substance intermediate, in properties, between albumen and fibrin. He considers it in the course of conversion from albumen to fibrin. It is not so fibrous, in its texture, as fibrin, or so easily acted upon by solutions of pure potash or of soda. When burnt, it leaves a charcoal, which is found to contain chloride of sodium (common salt), phosphate of lime, and traces of iron.

Its coagulum, intermediate between albumen and fibrin.

5. The liquid part of chyle becomes coagulated by heat, by alcohol and acids; hence, therefore, it contains albumen. After the albumen is separated, if the remaining liquid be evaporated to one-half, in a heat not exceeding 200°, on cooling, it deposites crystals, which Brande considers to be sugar of milk.

Its liquid part contains albumen and sugar of milk.

6. From the foregoing statement, there may be deduced the following constituents of chyle:

Water,
A substance intermediate in nature between albumen and fibrin,
Albumen,
Sugar of milk,
Phosphate of lime,
Chloride of sodium,
Iron.

7. These substances may be referred to the following ul-

Part II. Book III. timate constituents; namely, oxygen, chlorine, azote, hydrogen, carbon, phosphorus, sodium, calcium and iron.

8. The chemical account of chyle, here given, can be considered as applying to the chyle of the horse only. There can be very little doubt, however, that the chyle of man is the same in constituents, varying somewhat in the proportions in which they combine.

SECTION II.

OF BLOOD.

Blood described.

1. It can hardly be necessary to describe the general appearances of blood. In the more perfect animals, as in man for example, it has a red colour, an unctuous feel, a slightly saline taste, and a peculiar smell. The mean specific gravity of human blood is 1·0527.

It separates spontaneously into two parts, called serum and crassamentum.

2. Blood, soon after it is drawn, coagulates into a solid mass, which slowly separates into two parts; a liquid part, which is called serum, and a solid part, forming, as it were, an island in the former, which is called crassamentum. The crassamentum generally constitutes about one-fourth of the blood; but its quantity is not uniform. In some rare cases, it is said to compose one-half, and in others only one-fifth of the mass of the blood. The cause of the spontaneous decomposition of blood is not satisfactorily known. It takes place equally in close or in open vessels, or whether it be allowed to cool, or is preserved at the animal heat.

1. Serum described.

3. Serum is a light, greenish-yellow liquid, having the taste, smell and feel of blood, but much less consistency. Its mean specific gravity is 1·0287. It changes some vegetable blues to green, owing to the presence of soda. When heated to the temperature of 156°, or when mixed with boiling water, it coagulates, and the coagulum proves to be albumen. The coagulation, however, is prevented, if it be mixed with six times its weight of cold water. If the coagulum be cut into small pieces and squeezed, a liquid is forced out, which is called *serosity*. Besides albumen, serum contains a large proportion of water, holding in solution soda, lactate of soda, chlorides of sodium and of potassium (muriates of soda and of potash), and some animal matter.

Its composition, according to Berzelius;

4. Berzelius found the constituents, just enumerated, combined in the following proportions in the serum of human blood:

Water	905·0
Albumen	80·0
Chlorides of potassium and of sodium (muriates of potash and of soda)	6.0
Lactate of soda with animal matter	4.0
Soda, phosphate of soda with animal matter	4·1
Loss	0·9
	1000·0

5. Dr. Marcet found human serum composed as follows: according to Marcet.

Water	900·00
Albumen	86·80
Chlorides of potassium and of sodium (muriates of potash and of soda)	6·60
Muco-extractive matter	4.00
Subcarbonate of soda	1·65
Sulphate of potash	0·35
Earthy phosphates [of lime and magnesia]	0·60
	1000·00

6. Dr. Marcet's analysis agrees very nearly with that of Berzelius in the three first items. Dr. Thomson considers the muco-extractive matter of Dr. Marcet to be equivalent to the lactate of soda with animal matter of Berzelius's analysis. Berzelius detected, in serum, phosphate of soda, which does not appear in Dr. Marcet's analysis. The soda in the first analysis was no doubt in the state of subcarbonate, as stated in the second. The substances, stated in the two last items of Dr. Marcet's analysis, occur in exceedingly minute proportion. Their constituents, except the potash, are considered by Berzelius to be formed during incineration; their radicals, namely, sulphur, phosphorus, calcium and magnesium, being supposed by this chemist to be component parts of albumen. Berzelius's and Marcet's analyses compared.

7. The crassamentum of the blood has a red colour, and considerable consistency. Its mean specific gravity is about 1·245. When washed with water as long as this liquid abstracts any thing, a white elastic solid substance remains, which is found to possess all the properties of fibrin. The portion, which is carried off by the water, is the colouring matter of the blood. Besides these ingredients, there exists in the crassamentum a portion of albumen. 2. Crassamentum described.

8. From these statements, it appears, that the whole of the constituents of blood are the following: Constituents of blood.

Serum—composed of

Water.

Albumen.

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Chlorides of potassium and of sodium.
Lactate of soda with animal matter.
Soda, phosphate of soda with animal matter.
Crassamentum—composed of
Colouring matter of the blood.
Fibrin.
Albumen.

9. All these substances may be referred to the following ultimate constituents; namely, oxygen, chlorine, azote, hydrogen, carbon, phosphorus, sulphur, potassium, sodium, calcium, magnesium and iron.

Blood is different in different animals.

10. Very little has been done, in ascertaining the comparative nature of blood, in different animals, at different ages of the same animal, and as altered by disease. Rouelle examined the blood of a number of animals, and found the same constituents in all, though united in different proportions. Fourcroy has examined the blood of the human fœtus, and found it to differ from adult blood in the following particulars. It contained a larger proportion of colouring matter and of a darker colour. Albumen was present in it, but no fibrin or phosphoric acid.

Diseased changes of the blood.

11. The blood of persons, labouring under different diseases, has been examined by Deyeux and Parmentier. That peculiar appearance, which blood usually exhibits during inflammation, called the buffy coat, is found to be formed, in consequence of the subsidence of the colouring matter of the blood from the crassamentum, thereby leaving its fibrin, unmixed on the surface. This appearance of blood seems to depend upon the slowness with which it coagulates, or its want of viscidity. The blood, drawn from patients labouring under scurvy, was not found to differ from healthy blood, except in not being so easily coagulated. The serum of the blood of diabetic patients frequently puts on the appearance of whey. It has been ascertained, that blood, when drawn in this disease, contains no perceptible quantity of sugar.

SECTION III.

OF FECES.

The suite of changes in the food explained, which results in the formation of chyle and feces.

1. After the food has undergone certain changes in the stomach by the action of the gastric secretion, it passes into the duodenum, where it undergoes further changes by being mixed with the bile and pancreatic secretion. After experiencing these changes, it is fitted to afford chyle by the action of the lacteals; and accordingly these vessels separate this

milky fluid from the alimentary mass, especially in the small intestines, as it passes along the alimentary canal. The whole of the alimentary mass, however, is not fit for conversion into chyle; but a refuse part, unfit for the purposes of nutrition, is propelled successively through the whole length of the tube, and is ultimately discharged per anum. This refuse part constitutes the feces.

Analysis of feces, how conducted by Berzelius.

2. In order to elucidate the process of digestion, Berzelius, in 1806, undertook the disgusting task of analyzing human feces. The result of this chemist's researches will be given in the present section.

3. Feces are supposed to derive their colour from admixture of bile, which, being present in different proportions, causes their variety in this respect. Their odour is fetid and peculiar, and changes gradually to sourish. Their taste is sweetish-bitter.

4. The proportion of aqueous parts in feces is variable. As a medium, it may be considered that they lose about three-fourths of their weight in drying.

5. When feces are diffused through water by maceration and agitation, and the liquid, thus formed, strained through a linen cloth, there is obtained upon it about seven per cent. of a greyish-brown matter, which, upon being dried, proves to be the remains of animal and vegetable substances used as food. The strained liquid, upon standing, deposites a yellowish-green slimy matter, amounting to fourteen per cent. of the feces examined, which is found to be composed of three distinct substances: 1. A fatty matter, resembling picromel, taken up by alcohol; 2. A peculiar yellow-coloured substance, which may be separated by water; and, 3. A greenish-grey substance, neither soluble in water nor alcohol, which leaves, when incinerated, some silica and phosphate of potash. After this slimy matter is separated, the liquid which remains is at first of a light yellow colour, but afterwards, by exposure to the air, becomes brown, and at last muddy. When concentrated by evaporation, crystals of ammonio-phosphate of magnesia make their appearance. Besides this triple salt, the liquid is found to contain, 1. Albumen, amounting nearly to one per cent. 2. About the same proportion of a mixture of picromel and soda, which Berzelius considers as bile. 3. A peculiar reddish-brown substance, soluble both in water and alcohol, and precipitable by a small portion of tannin in the form of a red powder, in the amount of 2·7 per cent. 4. Various salts; namely, carbonate and sulphate of soda, and phosphate of lime, together with chloride of sodium (common salt). These substances, including the ammonio-phosphate of magnesia, constitute 1·2 per cent. of feces.

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Result of Berzelius's analysis.

6. The following statement gives the precise result of the analysis of 100 parts of feces, as conducted by Berzelius.

Water	73·3
Vegetable and animal remains	7·0
Slimy matter; consisting of altered picromel, a peculiar yellow soluble substance, and a greenish-grey insoluble substance	14·0
Albumen	·9
A mixture of picromel and soda	·9
A peculiar reddish-brown substance	2·7
Salts, &c.	1·2
	100·0

The analysis, not satisfactory.

7. The above analysis cannot be considered as very satisfactory. The chemist is presented with three substances, which have not been identified with any known forms of matter, and yet probably are not peculiar in themselves. These substances, including the altered picromel, amount to more than three-fourths of the feces, exclusive of the aqueous part and the animal and vegetable remains. Consequently, they compose the great bulk of this animal substance, and must be considered as its most characteristic part. It would be important to have the peculiar nature of these substances satisfactorily ascertained, or, otherwise, their identity with known forms of matter manifested. It certainly would be an object of curious inquiry to investigate the peculiarities in the constituents or manner of combination of matter, which render it unfit to be absorbed by the lacteals. Will any particular ultimate constituent be found redundant in such matter? This question deserves to be satisfactorily answered.

b. Secretions subservient to the Digestive Function.

These secretions are Saliva, Gastric Secretion, Pancreatic Secretion and Bile.

SECTION IV.

OF SALIVA.

Saliva described.

1. SALIVA is a limpid and somewhat viscid liquid, destitute of taste or smell. Its specific gravity is very little greater than that of water. It does not mix readily with water, but by trituration in a mortar, the union may be effected. It is said to absorb oxygen readily from air. When triturated with several of the metals, as gold, silver, or mercury, it is known to cause their oxidizement. When evapo-

rated, it swells exceedingly and leaves a brown-coloured crust. When distilled, it yields water, a little carbonate of ammonia, some oil, and an acid.

Its composition.

2. According to an analysis by Berzelius, 1000 parts of saliva are composed of

Water	992·9
Peculiar animal matter	2·9
Mucus	1·4
Chlorides of potassium and of sodium (muriates of potash and of soda)	1·7
Lactate of soda, and animal matter	0·9
Pure soda	0·2
	1000·0

3. In the above analysis, the peculiar animal matter possesses the properties of mucus, as heretofore detailed; while the mucus of Berzelius bears a close analogy to coagulated albumen.

4. The peculiar substance, in common language called tartar, which adheres to the teeth, was found by Berzelius to be composed principally of the phosphates of lime and of magnesia.

SECTION V.

OF THE GASTRIC SECRETION.

Gastric secretion, its nature but imperfectly ascertained.

1. Very little is known at present of the exact chemical nature of the gastric secretion. The accounts of different physiologists, who have examined it, are so discordant, that no precise notion of its composition, in the healthy state, can be formed from them. This discordancy, without doubt, is to be attributed, in part to the difficulty of obtaining this secretion pure, it being always mixed with the remains of food and often with bile; but principally to its natural variations, depending upon the nature of the food, the peculiar constitution of the animal, and upon the longer or shorter time after a meal, at which it is examined.

Different methods of obtaining it from the stomach.

2. Several methods have been employed by physiologists for obtaining the gastric secretion pure. One method is to kill an animal, after it has fasted for a considerable time, and to take the secretion from the stomach. Another method is to force animals to swallow tubes, perforated with holes and containing dry sponge, and afterwards to return them by vomiting. In this way, Spallanzani obtained a liquor from the stomach of crows, which he considered to be the gastric juice. No dependence, however, can be placed upon any

method for obtaining this secretion, of which vomiting makes a part; since in all cases, where the stomach is nearly empty, vomiting produces a discharge of bile. A third method, for obtaining the secretion, is to excite vomiting in the morning before taking food. This method, Spallanzani and Gosse practiced on themselves.

Its properties, according to Spallanzani.

3. Spallanzani found, that the liquid, which he threw up in the morning, and which he considers to be the gastric secretion in a pure state, had a saltish taste, without any mixture of bitterness. When first ejected, it was frothy and somewhat glutinous. Upon standing, it deposited a scanty sediment, and became as limpid as water. It had no tendency to putrefaction; for when kept in a stopped vial, for longer than a month, exposed to the heat of an Italian summer, it underwent no perceptible change.

Properties of the gastric secretion of inferior animals.

4. According to the observations of Brugnatelli, the gastric secretion of carnivorous animals has an acid and resinous odour and a bitter taste, is not at all watery, and consists of an uncombined acid, a resin, an animal substance, and a small portion of common salt. According to Spallanzani, who seems to have settled the point by experiment, the secretion in these animals, including man, is neither acid nor alkaline in its natural state; and becomes acid only by the use of vegetable food in large proportion, which property it derives from such aliment in its tendency to undergo the acetous fermentation. Again, Brugnatelli asserts, that the gastric secretion of herbivorous animals has a bitter, saltish taste, and contains ammonia, an animal extract, a pretty large proportion of common salt, and a large quantity of water. The gastric secretion of oxen and calves has been proved by Macquart and Vauquelin to contain, invariably, uncombined phosphoric acid.

Experimental information, very desirable on the subject of the gastric secretion.

5. It is much to be desired, that an elaborate analysis of the gastric secretion of man and other animals should be performed by some chemist well fitted for the task. It is not expected, that any light would be thrown upon the function of digestion by this research; for it would seem, that this operation has some hidden connection with vitality, with which chemistry can have no concern. This good, however, might fairly be expected to result from the investigation: it would illustrate the difficult disease of dyspepsia, by pointing out the chemical peculiarities of the secretion in particular cases, and thereby suggesting the appropriate remedies. It would also be productive of important advantages, by ascertaining in what cases of derangement in the digestive organs, the gastric secretion of particular animals would be serviceable as a remedy.

6. On the subject of the gastric secretion as a remedy, it may be proper to remark, that this liquid, derived from graminivorous animals, has been successfully employed as an external application to ill-conditioned ulcers, especially such as have a sloughing tendency, and are attended with great pain. The ulcer is bathed with the liquor, and then dressed with lint moistened with it. It is considered to act as a stimulating antiseptic. By its stimulus, it substitutes a healthy for a diseased action, and by its antiseptic qualities, it destroys the fœtor, which is an invariable attendant upon such ulcers. In some cases of indigestion, attended by vomitings of acid and black matter, and when the gastric secretion has lost its energy, the internal exhibition of the gastric liquor from ruminating animals, has been found by Carminati to be of great use. The dose employed was one ounce of the fresh secretion. This same philosopher was enabled to cure intermittents by the use of the liquor; in which cases, he increased the dose to three ounces a day.

CHAP. II.

The gastric secretion as a remedy.

SECTION VI.

OF THE PANCREATIC SECRETION.

1. NOTHING is known as to the chemical nature of this secretion. There is good reason, however, to believe, that it is very similar to the saliva.

Pancreatic secretion supposed to resemble saliva.

SECTION VII.

OF BILE.

1. HUMAN bile is a liquid, generally viscid, of a somewhat bitter taste. Its colour is variable, being sometimes green, sometimes yellowish, and occasionally nearly colourless. It usually contains a yellow matter, suspended in it. When evaporated to dryness, the residue is a brown mass, amounting to about $\frac{1}{11}$th of the weight of the bile experimented upon.

Human bile described.

2. According to an analysis by Berzelius, 1000 parts of human bile are composed of

Its composition.

Water	908·4
Picromel	80·0
Albumen	3·0
Soda	4·1
Phosphate of lime	0·1
Chloride of sodium (common salt)	3·4
Phosphate of soda with some lime	1·0
	1000·0

Ox bile and human bile compared.

3. By an analysis of ox bile performed by Thenard, it appears, that this liquid contains all the ingredients of human bile, as ascertained by Berzelius, except albumen; and the additional ingredients of resin, which may be considered as included under the title of picromel in Berzelius's analysis, yellow matter, which is probably equivalent to the albumen of the human bile, sulphate of soda, and oxidized iron. So that the real difference, between the bile of man and of the ox, consists in the presence of sulphuric acid and oxidized iron in the latter, not to be found in the former. Thenard examined the bile of the calf, the dog, the sheep, and the cat, and found it to resemble ox bile exactly in properties and constituents. On the other hand, the bile of the sow was found to differ entirely from that of the animals just mentioned; for it does not contain albumen, animal matter, or picromel.

Ultimate constituents of bile.

4. The substances, enumerated in Berzelius's analysis of human bile, may be all referred to the following ultimate constituents; namely, oxygen, chlorine, azote, hydrogen, carbon, phosphorus, sodium, and calcium.

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c. Secretions subservient to the Organs of Sense.

These secretions are Tears, the Mucus of the Nose, and the Cerumen of the Ear.

SECTION VIII.

OF TEARS.

1. The tears are a transparent colourless liquid, having scarcely any smell, but a perceptibly saltish taste. Their specific gravity is somewhat greater than that of distilled water. They change some vegetable blues to a green; which property they possess in consequence of the presence of uncombined soda. When exposed to the air, the aqueous portion gradually evaporates, and the residue assumes some consistency. When brought nearly to a state of dryness, cubic crystals of chloride of sodium (common salt), combined with a portion of soda, make their appearance. When evaporated completely to dryness, they lose 96 per cent. of water, and the residue is a yellow matter, having the properties of inspissated mucus. This mucus is insoluble in water, which is supposed to be owing to the absorption of oxygen. When it is burnt in the open air, the residuum

Analysis of tears, how conducted.

contains traces of phosphate of lime and phosphate of soda. These salts, together with the uncombined soda and the chloride of sodium, amount to about one per cent. in the constitution of tears.

2. From these data, it may be stated, that 100 parts of tears are composed of

Water	96
Mucus	3
Chloride of sodium, soda, phosphates of lime and of soda	1
	100

3. These substances may be all referred to one or other of the following ultimate constituents; namely, oxygen, chlorine, hydrogen, carbon, phosphorus, sodium and calcium.

SECTION IX.

OF THE MUCUS OF THE NOSE.

1. Berzelius gives the following analysis of the mucus of the nose. Mucus of the nose.

Water	933·7
Mucus	53·3
Chlorides of potassium and of sodium (muriates of potash and of soda)	5·6
Lactate of soda with animal matter	3·0
Soda	0·9
Albumen, and animal matter soluble in water but insoluble in alcohol, with a trace of phosphate of soda	3·5
	1000·0

SECTION X.

OF THE CERUMEN OF THE EAR.

1. Cerumen is that orange-yellow substance, commonly called ear wax, which is found in the auditory canal. It is secreted by glands situated on this canal, and is at first liquid, but becomes gradually concreted by the action of the air. Its taste is bitter. When heated on paper, it leaves an oily stain, and emits a slightly aromatic odour. Cerumen of the ear described.

2. Fourcroy and Vauquelin consider cerumen as composed of the following ingredients; 1. albumen, 2. an inspissated oil, 3. a colouring matter, 4. soda, 5. phosphate of lime. Its constituents.

d. Secretions contained in Circumscribed Cavities.

THESE secretions are Humours of the Eye, Liquor of the Pericardium, and Sinovia.

SECTION XI.

OF THE HUMOURS OF THE EYE.

Humours of the eye are the aqueous and vitreous humours, and the crystalline lens.

1. ANATOMISTS describe three distinct transparent substances as filling up the internal cavity of the eye, under the names of the aqueous and vitreous humours, and the crystalline lens. These substances have been examined chemically by Chenevix and Berzelius.

2. The experiments have been made chiefly on the eyes of sheep; so that the analyses, which will be given in this section, are to be considered as of the eye of this animal. But as there is no perceptible chemical difference between the humours of the human eye, and of the sheep's eye, whatever may be said of the humours of the latter may be considered applicable to those of the former.

Composition of the different humours.

3. Berzelius found that 100 parts of the aqueous humour are composed of

Water	98·10
Albumen	trace.
Muriates [chlorides], and lactates	1·15
Soda, with animal matter soluble only in water	0·75
	100·00

4. This chemist found the same ingredients, united in somewhat different proportions, in the vitreous humour.

5. 100 parts of the crystalline lens were found by Berzelius to be composed of

Water	58·0
Peculiar matter	35·9
Muriates [chlorides], lactates, and animal matter soluble in alcohol	2·4
Animal matter soluble only in water, with some phosphates	1·3
Portions of remaining insoluble cellular membrane	2·4
	100·0

6. The peculiar matter, mentioned in the foregoing analysis, was found to have all the characters of the colouring matter of the blood, except the colour. When burnt, it leaves a small residue, containing a very small quantity of iron.

7. Leopold Gmelin has been enabled to ascertain several of the properties of the black pigment, found on the choroid coat of the eye. He collected 75 grains of this substance from 500 eyes of oxen and calves. It has a blackish-brown colour, and no taste. When applied to the tongue, it adheres like clay. It is insoluble in water, alcohol, ether or oils, but dissolves in solutions of potash or of ammonia, from which it may be precipitated by acids. How far the black pigment, on the same coat of the human eye, may possess similar properties, remains yet to be ascertained.

Chap. II. Properties of the black pigment of the eye of the ox.

SECTION XII.

OF THE LIQUOR OF THE PERICARDIUM.

1. Dr. Bostock has examined this liquor, obtained from a boy who had died suddenly. He considers it to be composed of the following constituents.

Liquor of the pericardium.

Water	92.0
Albumen	5·5
Mucus	2·0
Chloride of sodium (common salt)	0·5
	100·0

SECTION XIII.

OF SINOVIA.

1. Sinovia is a peculiar slippery liquid, found in the capsular ligaments of joints, and intended to facilitate the motion of bones upon each other.

2. Margueron has analyzed this liquid, as it exists in the joints of the ox. How far it may be the same in the human joint remains yet to be ascertained. In the mean time, it may not be uninstructive to give the result of this chemist's analysis.

Analysis of the sinovia of the ox; how conducted by Margueron.

3. When sinovia is treated with alcohol, a white substance precipitates, possessing all the properties of albumen. After this is separated, the liquid continues as viscid as at first; but if acetic acid be added, it loses its viscidity, and there precipitates a peculiar fibrous substance, having the colour, smell, taste and elasticity of vegetable gluten. If this fibrous matter be separated, and the remaining liquid

concentrated by evaporation, crystals of acetate of soda are deposited, which indicate the presence of soda. When the sinovia is exposed to a dry atmosphere, its aqueous parts gradually evaporate, and there remains a scaly residuum, in which cubic crystals of chloride of sodium, and a saline efflorescence consisting of carbonate of soda make their appearance. When exposed to destructive distillation, the products are water, the same liquid containing ammonia, empyreumatic oil, and carbonate of ammonia. The residue is a coal, containing some phosphate of lime.

Its composition.

4. According to Marguerou, the constituents of sinovia just given are combined in the following proportions.

Fibrous matter	11·86
Albumen	4·52
Soda	·71
Chloride of sodium (common salt)	1·75
Phosphate of lime	·70
Water	80·46
	100·00

e. Secretions of an Excrementitious Nature.

THESE secretions are *Urine* and *Sweat*.

SECTION XIV.

OF URINE.

Researches into the nature of urine, made by several chemists.

1. THIS animal secretion engaged the attention of chemists at a very early period, as being the liquid from which phosphorus was first obtained. The labours of the early chemists were chiefly directed to obtaining the phosphoric salts. Scheele was perhaps the first chemist, who advanced considerably the knowledge of the component parts of urine, by discovering several substances not before suspected to exist in it. Since his time, Cruickshanks, Proust, Fourcroy and Vauquelin, and Berzelius have made a complete investigation of its properties.

Healthy urine described.

2. Healthy urine, at the time it is voided, is a transparent liquid, of a light amber colour, aromatic odour, and disagreeable bitter taste. Its specific gravity varies from 1·005 to 1·033. Upon cooling, it loses its aromatic odour, and acquires a urinous one. In a few days, by standing, it ac-

quires an odour resembling that of sour milk, and ultimately an alkaline smell. CHAP. II.

3. By much the greatest bulk of urine consists of water. Berzelius has ascertained, that, in healthy urine, 933 parts in the 1000 are water. It contains, 1. Water:

4. If urine be evaporated by a slow fire to the consistence of a syrup, it will have a deep brown colour, and exhale a fetid ammoniacal odour. When this syrup cools, it forms a crystallized mass, consisting of all the component parts of urine. If this mass be treated with four times its weight of alcohol and slightly heated, a part of it is dissolved, and the alcohol assumes a brown colour. If the alcoholic solution be distilled in a retort at a sand heat, until it is reduced to the consistence of a syrup, at which period all the alcohol will have been driven off, the mass obtained, upon cooling, assumes the form of crystals. These crystals consist of urea. This peculiar substance constitutes about 30 parts in every 1000 of urine, including the water; but if the aqueous portion be excluded, it forms nearly one-half of this secretion. Urea is characteristic of this liquid, and possesses its taste and smell. Its presence in urine may be detected, very readily, by evaporating this liquid to the consistence of syrup, and then adding concentrated nitric acid. This acid will fall down, combined with the urea, in the form of white shining crystals.* 2. Urea, which is its characteristic ingredient:

5. Urine is capable of converting some vegetable blues to red. The uncombined acid, which is thereby indicated, was first supposed to be the phosphoric acid, and afterwards the acetic acid by Thenard; but Berzelius has shown, that it is the lactic acid. Besides uncombined lactic acid, Berzelius has detected in urine, lactate of ammonia, and a peculiar animal matter together with some urea which cannot be separated from it. These three ingredients, according to Berzelius, constitute 17·14 parts of urine in the 1000. 3. Lactic acid, lactate of soda and animal matter:

6. If urine be slowly evaporated to the consistence of syrup, a number of crystals will make their appearance on its surface. These crystals are found to consist of chloride of sodium (common salt). 4. Chloride of sodium:

7. If urine be acidulated with nitric acid to prevent the precipitation of the phosphates which it contains, upon the addition of chloride of barium (muriate of barytes), a precipitate falls consisting of sulphate of barytes. This precipi- 5. Sulphates of potash and of soda:

* The reader, who wishes to have a clear idea of the nature of urine, would do well to recur to the sections, which describe uric acid and urea, to refresh his memory on the subject of their properties.

tation demonstrates the presence of sulphuric acid in urine. It has been ascertained, that it exists in combination with potash and soda. These facts were made known by Berzelius.

8. If the saline mass, which remains after the separation of urea by the action of alcohol from crystallized urine, be dissolved in a sufficient quantity of hot water, and allowed to crystallize spontaneously in a close vessel, two distinct sets of crystals will be formed. They may be separated from each other by exposure to a dry atmosphere; the uppermost set will effloresce and fall to powder, while the lowermost set will remain unaltered. The former is found to consist of phosphate of soda united to a small quantity of phosphate of ammonia; whereas the latter is composed of phosphate of ammonia combined with a small portion of phosphate of soda. These salts, as they exist in the impure saline mass above alluded to, were formerly known by the names of fusible salt of urine and microcosmic salt.

6. Phosphate of soda and of ammonia.

9. When urine is cautiously evaporated, cubic crystals may often be discovered among its salts. These crystals are ascertained to consist of hydrochlorate (muriate) of ammonia.

7. Hydrochlorate of ammonia:

10. If liquid ammonia be added to fresh urine, a white powder precipitates, which is found to be phosphate of lime containing a little magnesia. The magnesia is ascertained to be derived from some phosphate of magnesia, which is decomposed by the action of the ammonia. The phosphate of lime contains also, according to Berzelius, a minute portion of hydrofluate (fluate) of lime.

8. Phosphates of lime and of magnesia, and hydrofluate of lime:

11. If urine be evaporated to $\frac{1}{16}$th part of its weight, it lets fall a subtle powder, which adheres firmly to the bottom of the vessel employed. This substance is uric acid. The quantity of this acid contained in urine is very variable. The brick-red substance, which is deposited when urine cools, is composed of phosphate of lime and uric acid. The presence of the uric acid may be made evident by dissolving the sediment in diluted nitric acid. If the solution, upon being evaporated to dryness, assume a fine rose colour, uric acid is present. This solution consists of purpurate of ammonia.

9. Uric acid:

12. The cloud, which forms in urine as it cools, is ascertained to consist of the mucus of the bladder. It may be separated by the filter.

10. Mucus: and

13. Besides the substances already enumerated as constituents of urine, Berzelius has detected a very minute portion of silica in healthy urine.

11. Silica.

14. The following table exhibits the result of Berzelius's analysis of 1000 parts of healthy urine. CHAP. II. Constituents of urine according to Berzelius.

Water	933·00
Urea	30·10
Free lactic acid; lactate of ammonia; and animal matter, containing urea not separable from it	17·14
Chloride of sodium (muriate of soda)	4·45
Sulphate of potash	3·71
Sulphate of soda	3·16
Phosphate of soda	2·94
Phosphate of ammonia	1·65
Hydrochlorate (muriate) of ammonia	1·50
Phosphates of lime and of magnesia, with a trace of hydrofluate (fluate) of lime	1·00
Uric acid	1·00
Mucus of the bladder	0·32
Silica	0·03
	1000·00

15. Besides these constituents of urine, as ascertained by Berzelius, other chemists have detected substances not mentioned by him. Besides these constituents, there have been detected by others,

16. When fresh urine is put under the receiver of an air-pump, air bubbles are extricated, which prove to consist of carbonic acid. The presence of this acid in urine was first ascertained by Proust. 1. Carbonic acid:

17. If hydrochloric (muriatic) acid be added to fresh urine, previously evaporated to the consistence of a syrup, a precipitate appears, which has all the properties of benzoic acid. The quantity of this acid in urine varies in amount from one to ten parts in 10,000. 2. Benzoic acid:

18. If an infusion of tannin be dropt into urine, a white precipitate appears, which has been ascertained to consist of tannin, combined with albumen and gelatin. This precipitate, according to Cruickshanks, amounts to one part in 240 of healthy urine. 3. Albumen and gelatin: and

19. When urine is boiled in a silver basin, it blackens the metal; and if employed in sufficient quantity, small crusts of sulphuret of silver are formed. These facts prove the presence of uncombined sulphur in urine. 4. Sulphur.

20. Hence it appears, that, besides the substances enumerated in Berzelius's analysis, urine contains carbonic and benzoic acids, albumen and gelatin, and sulphur.

21. The ultimate constituents of urine are oxygen, chlorine, fluorine, azote, hydrogen, carbon, phosphorus, sulphur, potassium, sodium, calcium, magnesium, and silicum.

22. The urine is altered considerably in its properties, under the different circumstances of health and disease. In the following paragraphs, the most remarkable of these alterations are noticed.

23. The quantity of urea contained in urine is very variable. In the urine voided soon after a meal, scarcely any urea can be detected. In chronic hepatitis, Rose has ascertained, that the urine contains no urea. This fact has been confirmed by Dr. Henry. The urine which flows during hysterical paroxysms is known to be abundant and quite limpid. Urine, voided under such circumstances, contains scarcely any urea or gelatin, but a large proportion of salts.

24. Phosphate of lime is said to abound in the urine of rickety patients. The presence of this salt in excess, in the urine, might very reasonably be expected in this disease. It is, however, contended by some, that the morbid peculiarity of the urine of rickety patients consists in the presence of oxalate of lime.

Pink-coloured sediment of urine.

25. The pink-coloured sediment, which appears towards the close of some diseases, and is called by physicians the lateritious sediment from its brick colour, was considered by Scheele to consist of uric acid, mixed with some phosphate of lime. Proust, however, finds the acid of this sediment to differ from uric acid in several particulars; and, considering it as peculiar, has given it the name of rosacic acid. According to Proust, the lateritious sediment is composed of rosacic acid, mixed with a small proportion of uric acid and phosphate of lime. Prout considers it probable, that it is his newly discovered acid (purpuric acid), combined with ammonia, or perhaps occasionally with soda.* This sediment is deposited towards the termination of fevers, especially of the intermittent type. It falls also towards the termination of a paroxysm of gout, and during the course of diseases of the liver. Attention to the appearance of this sediment in urine becomes important, as it indicates the close of most inflammatory diseases.

Albumen of urine, encreased in general dropsy, but not in dropsy from diseased liver.

26. The quantity of albumen in urine is very much increased in certain diseases. It has already been stated, that the proportion of this substance in healthy urine is very small. In general dropsy, the urine is loaded with albumen, which may be coagulated by heat, or at least by acids. In dropsy, however, complicated with disease of the liver, the urine contains no albumen, but is high-coloured and scanty, and deposites the lateritious sediment. When the digestive

* Prout, Phil. Trans. (1818). Part II. 420.

process is imperfectly performed, the urine is found to furnish a copious precipitate with tannin. This precipitate is ascertained to be tannin, combined with albumen and gelatin. The presence of albumen and gelatin, in large proportion in urine, is indicated, if it speedily take on the putrefactive process. In some cases, urine becomes putrid as soon as voided. This occurrence may always be taken as a sure indication of some defect in the powers of the digestive organs.

CHAP. II.

Urine contains bile in jaundice:

27. Bile is sometimes found in small quantities in the urine, especially in jaundice. It may be detected by the addition of hydrochloric acid, which, if bile be present, will render the urine green.

and saccharine matter in diabetes.

28. The urine, in the disease called diabetes, has a sweet taste, and is found to contain a large quantity of saccharine matter. In one case, recorded by Dr. Bostock, the sugar contained in the urine, which a patient discharged in twenty-four hours, amounted to twenty-nine ounces.

Urine putrefies quickly, on account of the tendency to decomposition of urea.

29. The tendency of urine to putrefaction seems to depend upon the facility, with which its most remarkable ingredient, urea, suffers decomposition. The products of this decomposition are acetic and carbonic acids, and ammonia; and hence the ammoniacal smell, which attends the putrefaction of urine. The ammonia, thus formed, neutralizes the free lactic acid present in the urine; and, as a consequence, the phosphate of lime precipitates, it having been held in solution by this acid. It also combines with the phosphate of magnesia, with which it forms a triple salt. It neutralizes the uric and benzoic acids naturally present in the urine, and likewise the acetic and carbonic acids, the products of the putrefaction. Notwithstanding all these combinations, into which the ammonia enters, it still remains in excess. From this statement, it may be inferred, that the putrefaction of urine results in the formation of a number of salts, all of which contain ammonia.

SECTION XV.

OF SWEAT.

Matter is constantly issuing from the skin.

1. It has been ascertained by experiment, that an invisible vapour is constantly separating from the surface of the body. This vapour is called insensible perspiration. Under peculiar circumstances, however, the matter, which passes through the skin, assumes the liquid form, and then it is known by the name of sweat.

Part II. Book III.

Amount of insensible perspiration, calculated by several experimenters.

2. The amount of the insensible perspiration, for a given time, has not been precisely determined. Cruickshanks, who ascertained the insensible perspiration of the hand for a given time, calculates that for the whole body, to be, on an average, seven pounds six ounces troy, for twenty-four hours. Lavoisier and Seguin made experiments of a much more accurate nature, to elucidate the same point. These chemists noted the weight, lost by an individual, in a given time, both by respiration and perspiration. They afterwards ascertained the loss, for the same time, by respiration alone. This they were enabled to do, by enclosing the same person in a bag of varnished silk, completely impervious to air or vapour, and so arranged, by glueing the edge of a slit in it to the circumference of the mouth, as that respiration might be carried on in the open air without inconvenience. By this contrivance, all the matter emitted by the lungs was lost, while that emitted by the surface of the skin was retained in the bag. The difference in weight of the subject of the experiment, just after entering the bag and just before leaving it, must give the amount of loss by respiration alone; and this amount, subtracted from the loss occuring on both accounts, will give the amount of the insensible perspiration. In this way, Lavoisier and Seguin ascertained, that the maximum of perspired matter in a minute was 26·25 grains troy, and the minimum, 9 grains; which, calculated at a medium, gives 4 lbs. 4·89 ounces as the average amount of perspired matter for twenty-four hours.

Sweat contains, 1. Water:

3. Sweat is chiefly composed of water; but besides this liquid, several other substances have been discovered in it.

4. Air, which has remained for a long time in contact with the skin, is found to consist almost entirely of carbonic acid. There being no increase in the bulk of the air thus changed, it becomes a question, how the change is effected.

2. Carbon:

Either carbon must be emitted and afterwards become carbonic acid, or oxygen gas must be absorbed and carbonic acid ready formed be subsequently thrown out.

3. Lactic acid:

5. Sweat contains an acid. This was at first supposed to be the phosphoric acid, and afterwards, by Thenard, acetic acid; but Berzelius has rendered it probable, that the acid of sweat is the lactic acid.

4. Animal matter:

6. A small quantity of animal matter was obtained from sweat by Thenard. This chemist supposes it to be similar to gelatin in its nature.

5. Oily matter.

7. Besides these ingredients, sweat undoubtedly contains an oily matter, from which Cruickshanks believes it to derive its odorous properties. It is well known, that the dog can distinguish his master by the scent. This seems to

Chap. II.

prove, not only the odorous nature of the perspiration, but also its peculiarity in every individual. In the negro, the odorous part of the perspiration is in great abundance.

f. Secretions dependent upon Sexual Organization.

These secretions are Semen, Milk, and the Liquor of the Amnios.

SECTION XVI.

OF SEMEN.

1. Semen is the liquid, secreted by the testes, and intended for the impregnation of the female. Heretofore only human semen and the milt of certain fishes have been subjected to analysis. It is intended in this section to notice the chemical nature of the former.

Analysis of human semen.

2. Vauquelin analyzed human semen in 1794, and found it to be possessed of the following properties. When newly ejected, it is evidently a mixture of two different substances; the one, liquid and milky and considered to be the secretion of the prostate gland, the other, thick and mucilaginous, which appears to be the true secretion of the testes. Its smell is slightly disagreeable, and its taste acrid and irritating. Its specific gravity is greater than that of water. As it cools, the mucilaginous part becomes transparent, and acquires greater consistency; but, by the expiration of twenty minutes, it has liquefied. Before this spontaneous liquefaction, semen is insoluble in water, but afterwards dissolves in this liquid.

3. Vauquelin gives the following constituents for 100 parts of semen:

Water	90
Mucilage [mucus]	6
Phosphate of lime	3
Soda [carbonate of soda]	1
	100

SECTION XVII.

OF MILK.

1. Milk is the peculiar liquid, secreted by certain glands, with which the female of a particular class of animals called Mammalia is furnished, and intended for the nourishment of the offspring.

Part II. Book III.

Cows' milk, noticed in this section.

2. According to the plan proposed to be adopted in this work, human milk should alone come under notice. But as cows' milk constitutes a very important part of the food of man, and is the milk upon which the greatest number of experiments have been made; it is proposed in this section to give the analysis of cows' milk, and afterwards to take a comparative view of human milk.

Its properties.

3. The sensible qualities of cows' milk are too well known to require detail. Its boiling and freezing points are very nearly the same with those of water. Its specific gravity is between that of water and of blood. It reddens vegetable blues.

It is easily separated into 3 parts; cream, curd and whey.

4. Milk may be readily separated into three parts. When allowed to remain at rest for some time, a thick unctuous yellow substance collects on its surface, denominated cream. After this substance is separated by skimming, the liquid which remains is much thinner than unskimmed milk, and has a bluish-white colour. Skim-milk, by being heated to the temperature of about 100° and the addition of a little rennet,* coagulates into a solid tremulous mass. This mass, upon being broken into pieces, separates into two distinct parts; the one solid called curd, the other liquid called whey.

1. Cream consists of butter, mixed with curd and whey.

5. The peculiar nature of cream is derived from the presence of a concrete oil; but besides this oil, cream contains both curd and whey. The oil may be separated from the curd and whey by agitation. It constitutes the well known article of food, called butter; and the mechanical process, by which it is separated, is called churning.

6. Butter, as it is commonly made, still contains a portion of curd and of whey. If heated to the temperature of 96°, it melts, becomes transparent, and has the appearance of an oil. If kept for some time in a melted state, a little curd and whey separate from it; but, after this separation, it has lost its peculiar flavour.

7. Berzelius has ascertained, that the ingredients of cream are united in the following proportions:

Butter	4·5
Cheese [curd]	3·5
Whey	92·0
	100·0

8. Thus it appears, that cream contains between 4 and 5 per cent. of butter; and that butter-milk consists of curd and whey without any oily part.

* Rennet is water, which has been digested upon the inner coat of the calf's stomach, and preserved with salt.

9. Butter may be obtained by agitating or churning milk newly drawn from the cow; and in this case a larger proportion of butter is afforded. It has been ascertained also, that skim-milk and even whey still continue to contain a portion of the oily part of milk, and may be made to yield butter by churning. Sour cream, however, is generally preferred for making butter. Such cream yields as much butter as fresh cream, and requires but one-fourth as much churning. It is not known in what way the acidity of the cream operates; but it has been observed, that butter produced from such cream is as sweet as any other, while the butter-milk itself is not so sour as the cream from which it had been formed. Hence there is an evident disappearance of acidity. The manner in which churning acts is not well understood. It is said to effect the separation of butter, even though the contact of air be prevented.

Chap. II.

Butter obtained by churning milk.

10. The usual means, by which skim-milk is separated into curd and whey, have already been pointed out. Curd is a white solid substance, possessing a good deal of brittleness when completely separated from the aqueous parts. It may be precipitated from skim-milk by means of acids, which fall in combination with it. It may be afterwards disengaged from these combinations, by digesting them in the solution of some salifiable base, which forms an insoluble compound with the acid present. The acid combines with such base, and the liberated curd dissolves in the water. Curd, rendered soluble in this way, is somewhat altered in its properties. Its solution has a yellow colour, and some resemblance in appearance to a solution of gum. When evaporated to dryness, it leaves a yellow mass, which is readily soluble in water. When its solution is boiled, a pellicle forms upon its surface, nearly insoluble in water, and similar to that, which is formed upon boiling milk. Curd appears to be closely allied to coagulated albumen in properties. It is composed of oxygen, azote, hydrogen and carbon.

2. Curd described.

It is a kind of coagulated albumen.

11. Curd is the part of milk from which cheese is made. The richness and good quality of this article of food depend very much upon the quantity of the cream or oily part of milk, which may be allowed to remain in it. If the curd be too much heated and too forcibly pressed, a rich whey is driven out, and an inferior cheese is formed. On the contrary, if the heat be not so great, and a slow and gentle pressure be employed, the oily part of the milk remains in the cheese, a very thin and colourless whey only being forced out.

It forms the basis of cheese.

12. Whey, as it is generally obtained, is rendered impure by admixture of curd. It may be separated from the

3. Whey described.

latter by first filtering, and afterwards boiling it for some time, and carefully separating the scum which collects on its surface. Whey, when thus rendered pure, is a transparent liquid of a yellowish-green colour and sweetish taste. It reddens vegetable blues, owing to the presence of lactic acid. The greater part of it consists of water. When slowly evaporated, it at last deposites a number of white crystals consisting of sugar of milk. Besides this substance, it contains the chlorides of sodium and of potassium (muriates of soda and of potash), the phosphates of lime and of magnesia, sulphate of potash, a peculiar extractive, and, according to Fourcroy and Vauquelin, phosphate of iron.

Composition of 1000 parts of skim-milk.

13. According to Berzelius 1000 parts of milk, deprived of its cream, are composed of

Water	928·75
Curd with a little cream	28·00
Sugar of milk	35·00
Chloride of potassium (muriate of potash)	1·70
Phosphate of potash	0·25
Lactic acid, acetate of potash, with a trace of lactate of iron	6·00
Earthy phosphates (phosphates of lime and of magnesia)	0·30
	1000·00

14. This analysis of Berzelius of skim-milk, by excluding the curd, may be considered as giving the constituents of whey. When taken with this exception, it is perceived, that it indicates the same constituents for this part of milk, as those already given upon the authority of other chemists; with the exception of chloride of sodium (common salt), sulphate of potash and phosphate of iron, not found by Berzelius, and with the addition of phosphate and acetate of potash, and lactate of iron, detected by this chemist alone. With regard to the iron, it is seen, that Berzelius differs, from Fourcroy and Vauquelin in finding it combined with lactic acid, instead of phosphoric acid.

15. As cream is composed of butter, curd and whey, Berzelius's analysis of skim-milk may be considered as containing every ingredient of milk, except the oil or butter. Taking his analysis, therefore, with this addition, milk may be stated as having the following ultimate constituents; namely, oxygen, chlorine, azote, hydrogen, carbon, phosphorus, potassium, calcium, magnesium and iron.

Woman's milk, compared with cows' milk.

16. Woman's milk differs from cows' milk in the following particulars. Its taste is much sweeter. It forms, when allowed to remain at rest, a more abundant cream,

which, however, cannot be made to yield butter. It does not coagulate by any of the means which succeed with cows' milk; but this does not depend upon the absence of curd, but arises from the small portion which it contains of that ingredient of milk. Human milk yields a larger proportion of sugar of milk than cow's milk. These are the principal differences between cows' milk and human milk.

SECTION XVIII.

OF THE LIQUOR OF THE AMNIOS.

Liquor of the amnios, the liquid in which the fœtus swims.

1. The fœtus in utero is contained in a membranous bag, called the amnios. The liquor of the amnios is the liquid, with which this bag is filled, and in which the fœtus swims.

2. This liquor, in the human female, has a slight milky colour, a weak pleasant odour, and a saltish taste. When evaporated to dryness, 98·8 per cent. are driven off in the form of water, and the residue, amounting to 1·2 per cent. consists of albumen, chloride of sodium (common salt), carbonate of soda, phosphate and carbonate of lime.

III. *MORBID PRODUCTS.*

Morbid products are either secretions or concretions.

The morbid products of the human body come next under consideration: These are either

a. Morbid secretions; as pus, liquor of dropsy, and liquor of blisters; or

b. Morbid concretions; which will be noticed under the titles of concretions with basis of phosphate of lime, biliary concretions, urinary concretions, and gouty concretions.

Morbid products, thus arranged, will be treated of in the seven following sections.

a. Morbid Secretions.

These secretions are, Pus, Liquor of dropsy, and Liquor of blisters.

SECTION I.

OF PUS.

Pus is of different kinds.

Pus is the thick liquid, secreted generally by the surface of an open sore. There are, however, a great many shades of difference in this animal product, as secreted from sores

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in different states. One kind of it, which always attends an ulcer while in a healing condition, is generally called good pus. It is proposed first to consider this kind, and afterwards those modifications, which do not indicate a reparation of injured parts.

Good pus described.

I. *Good pus* is a liquid about the consistence of cream. It has a yellowish-white colour, an insipid taste, and no smell when cold. When viewed through the microscope, it has the appearance of a transparent liquid, in which white globules are swimming. Its specific gravity is somewhat greater than that of water. Hence, when thrown into this liquid, it sinks. It does not mix readily with water. By slight agitation, it forms a milky liquid, but the pus subsides again by rest. Nevertheless, by repeated agitation, a permanent mixture may be formed, which passes through the filter unaltered.

Action of the stronger acids;

Pus forms with sulphuric acid a purple-coloured solution, from which it may be precipitated by the addition of water. It dissolves with effervescence in concentrated nitric acid, forming a yellow-coloured solution, from which when recent it may be thrown down, in the form of grey flakes, by the addition of water. A similar solution may be made in hydrochloric acid by the assistance of heat, and decomposed in like manner. The facts, last stated, are sufficient to distinguish pus from mucus, a discrimination of some importance with regard to expectorated matter.

and of alcohol.

Pus, when treated with alcohol, is not dissolved, but thickened. With solutions of potash or soda, it forms a whitish ropy liquid, which is decomposed by water. Ammonia first reduces it to the state of a transparent jelly, and then dissolves it partially.

When pus is dried at a moderate heat, it assumes the appearance of horn. When exposed to destructive distillation, the chief products are water, ammonia, carbonate of ammonia, and an empyreumatic oil. The residuum is a light brilliant coal, containing traces of iron.

No precise analysis has been made of pus; but from what has been already said, it is obvious, that it bears considerable analogy to albumen.

Ill-conditioned pus is of several kinds.

II. *Ill-conditioned pus.*—There are a great many shades of difference in ill-conditioned pus. It has an acrid irritating nature, a fetid smell, and much less consistence than good-conditioned pus. That secreted by what is called the hospital sore has been examined by Mr. Cruickshanks. It possessed most of the properties of good-conditioned pus. Its fetid odour was not destroyed, but changed by lime water: it was increased by sulphuric acid or alcohol; but was des-

troyed by nitric acid and nitrate of mercury, by perchloride of mercury and chlorine. These latter substances, therefore, are considered by Cruickshanks as the proper washes for destroying the fœtor of ill-conditioned ulcers.

Matter formed by cancer, described.

III. *Matter of cancer.*—This matter has been examined by Dr. Crawford. It changes some vegetable blues to green, indicating the presence of an alkaline base. When treated with sulphuric acid, a gas is extricated, having the properties of hydrosulphuric acid (sulphuretted hydrogen). Dr. Crawford supposes, that this acid exists in the matter combined with potash. Its odour is completely destroyed by chlorine. Hence this supporter is recommended as the best wash for cancerous ulcers.

Expectorated matter.

IV. *Expectorated matter.*—Dr. Pearson has examined with much care the different kinds of expectorated matter, of which he enumerates seven. All these kinds, excluding true pus, he finds to consist of water, holding in solution a quantity of albumen in a state of combination with potash, together with a number of salts in small proportion, and traces of sulphur, phosphorus, and oxidized iron.

SECTION II.

OF THE LIQUOR OF DROPSY.

Liquor of dropsy described.

1. This liquor has a yellowish-green colour, and is sometimes transparent and sometimes turbid. A colourless liquor, extracted from a dropsical patient and examined by Wurzer, was found to contain albumen, mucus, hydrosulphuric acid (sulphuretted hydrogen), phosphate of lime, chloride of sodium (common salt), and soda. Dr. Bostock analyzed a liquor, obtained by puncturing a tumour on the spine, and found it composed of the following constituents.

Water	97·8
Chloride of sodium (muriate of soda)	1·0
Albumen	0·5
Mucus and gelatin	0·7
Lime	trace
	100·0

SECTION III.

LIQUOR OF BLISTERS.

Constituents of the liquor of blisters.

1. Margueron has ascertained, that this liquor is composed of the following constituents.

Water	78
Albumen	18
Chloride of sodium (muriate of soda)	2
Carbonate of soda	1
Phosphate of lime	1
	100

b. Morbid Concretions.

These are, Concretions with basis of phosphate of lime, Biliary Concretions, Urinary Concretions, and Gouty Concretions.

SECTION IV.

CONCRETIONS WITH BASIS OF PHOSPHATE OF LIME.

Concretions with basis of phosphate of lime are,

UNDER this title may be enumerated the following concretions.

1. Pineal concretions.

I. *Pineal concretions.*—Small concretions, about the size of grains of sand, are frequently found in that part of the brain, called the pineal gland. Dr. Wollaston has ascertained that they are composed of phosphate of lime.

2. Salivary concretions.

II. *Salivary concretions.*—Small concretions are sometimes found in the salivary glands, especially the parotid and sublingual. By the experiments of Wollaston, Fourcroy and others, it is ascertained, that these bodies are composed of phosphate of lime, together with a membranous substance, which remains undissolved, preserving the shape of the concretion, after the phosphate is removed by the action of an acid. The pancreatic concretions are supposed not to differ from these concretions.

3. Pulmonary concretions.

III. *Pulmonary Concretions.*—Small, round, white concretions are frequently coughed up by persons suffering under diseases of the lungs. They are found generally to consist of phosphate of lime, united to a membranous substance, which remains and retains the shape of the concretion, after the phosphate itself is removed by a corrosive acid. Occasionally these concretions have been found to be composed of carbonate of lime.

SECTION V.

OF BILIARY CONCRETIONS, OR GALL-STONES.

1. CONCRETIONS occasionally form in the gall-bladder, and, by getting into the gall-duct, prevent the flow of the bile into the intestines, and are thereby a cause of jaundice. It is, therefore, of some importance to the practitioner to be acquainted with the chemical nature of these substances. Biliary concretions form in the gall-bladder.

2. Several different kinds of biliary concretions have been distinguished, founded upon their external characters. They are of several kinds.

3. One species has a white colour, and a crystallized, shining, lamellated structure. Occasionally its colour is yellow or greenish. One only of this kind of biliary concretion is found at a time in the gall-bladder. It is sometimes as large as a pigeon's egg, but generally much smaller. It is formed invariably upon a nucleus of inspissated bile. Its specific gravity is less than that of water. When exposed to a heat of about 278°, it softens and melts, assuming the appearance of oil and giving out at the same time the odour of melted wax. When the heat is withdrawn, it again crystallizes as it solidifies. It is insoluble in water, but dissolves in hot alcohol, from which it deposites in brilliant plates upon cooling. It is soluble also in oil of turpentine. From these facts, it is evident, that this species of concretion is composed of a peculiar matter. This matter, from its resemblance both to fat and wax, was called by Fourcroy *adipocire*. Chevreul, however, has examined it more lately, and finds it to possess properties, distinct from those of adipocire, and proposes to call it *cholesterine*. Pelletier and Caventou have investigated the action of nitric acid on this substance, and find that it becomes converted into a peculiar acid substance, which they propose to call cholesteric acid. This new acid is capable of forming salts with the different salifiable bases.

4. Biliary concretions, belonging to the species next to be noticed, have a polygonal shape, and light greyish-brown colour. When broken they exhibit a structure, composed of an exterior thin crust, consisting of concentric layers alternately crystallized, and enveloping a nucleus, formed of a substance resembling granulated honey. Dr. Thomson analyzed six gall-stones of this kind, and found them to contain 96 per cent. of *adipocire*. The remainder was made up of some picromel, and a very small portion of a substance resembling albumen.

5. Besides these kinds of biliary concretions, Thenard has described a species consisting of altered matter of bile;

and Dr. Saunders another, the stones belonging to which are insoluble both in alcohol and spirits of turpentine, are not inflammable, but, when exposed to heat, become red, and waste away to ashes.

SECTION VI.

OF URINARY CONCRETIONS.

Urinary concretions are such as form in the bladder.

1. It is well known, that concretions sometimes form in the human bladder, and give rise, by their presence, to one of the most painful diseases, to which the body is liable.

2. At an early period, these concretions engaged the attention of physicians and chemists; in the hope, that the investigation, by ascertaining their constituents, might lead to the discovery of the proper solvents when the stone is already formed, or, when the tendency only to the formation is manifested, of the appropriate means of prevention.

First accurately examined by Scheele and Bergman in 1776; who were followed in the investigation by Wollaston in 1797; by Pearson in 1798; by Fourcroy & Vauquelin in 1799; and by Brande in 1808.

3. Very little advance was made in the investigation, until Scheele, in 1776, published a dissertation on the subject in the Stockholm Transactions; which was followed by some remarks by Bergman. No very important additions were made to the observations of Scheele and Bergman, until 1797, when Dr. Wollaston's experiments and observations appeared in the Philosophical Transactions, followed the next year by a paper from Dr. Pearson on the same subject. The labours of these chemists were succeeded by a most complete dissertation on urinary calculi by Fourcroy and Vauquelin in 1799; in the course of which, these chemists give the result of their analysis of 500 calculi. In 1808, Brande published a paper in the Philosophical Transactions, in which he gives the result of the analysis of 150 calculi from the Hunterian Museum.

4. Urinary calculi are very various, both in their external appearance and in their composition. It would, therefore, be impossible to describe them in general terms. It is proposed first to give an account of all the substances hitherto discovered in calculi, and afterwards the description of the different species of these concretions, as founded upon their various chemical constitutions.

Eleven substances have been detected in calculi.

5. The substances, heretofore discovered in urinary calculi, are the following:

1. Uric acid.	6. Magnesia.
2. Phosphate of lime.	7. Phosphate of iron.
3. Phosphate of magnesia-and-ammonia.	8. Silica.
4. Oxalate of lime.	9. Urea.
5. Hydrochlorate (muriate) of ammonia.	10. Cistic oxide.
	11. Mucus.

[1.] It has already been mentioned, that uric acid was discovered by Scheele, while analyzing urinary calculi. It is by far the most characteristic ingredient of urinary concretions. All those analyzed by Scheele consisted entirely of this acid. It was found in almost all the calculi analyzed by Pearson, Fourcroy and Vauquelin, and Brande, in larger or smaller amount. Of 150 concretions analyzed by Brande, sixteen were found entirely composed of this acid. The presence of uric acid is easily manifested by dissolving any calculus in a solution of potash or of soda, and precipitating the solution formed by the addition of a weak acid. The precipitate, if it consist of uric acid, will form the pink solution of purpurate of ammonia with nitric acid.

Chap. II.

1. Uric acid, discovered in them by Scheele.

2.] Phosphate of lime was first detected as an ingredient of urinary calculi by Bergman. It was afterwards found by other chemists, but Wollaston was the first to discover calculi entirely composed of this salt. They were of a brown colour, smooth externally and polished, and composed of concentric layers, easily separable from each other. Calculi of the same chemical nature, examined by Fourcroy and Vauquelin, were white, friable, and stained the hands.

2. Phosphate of lime first detected by Bergman.

[3.] Calculi, containing phosphate of magnesia-and-ammonia, were first noticed by Tennant, but were afterwards more fully investigated by Wollaston, and Fourcroy and Vauquelin. This triple salt usually occurs in white semitransparent layers, but sometimes on the surface of the calculus in crystals.

3. Ammonio-phosphate of magnesia.

[4.] Oxalate of lime was first detected in urinary calculi by Dr. Wollaston. Its presence characterizes the species of this concretion, previously denominated mulberry calculi from their shape. Calculi of this kind, examined by Dr. Wollaston, contained also phosphate of lime and uric acid; but Fourcroy and Vauquelin found some of this species combined only with animal matter.

4. Oxalate of lime first detected by Dr. Wollaston.

[5.] Hydrochlorate (muriate) of ammonia was first detected in calculi by Brande; who considers this to have been in reality the ammoniacal salt present in urinary calculi, announced as a urate by Fourcroy and Vauquelin. Accordingly Brande does not believe, that any such salt as urate of ammonia exists in concretions of the bladder.

5. Hydrochlorate of ammonia first noticed by Brande.

[6.] Alemani, an Italian apothecary, has detected magnesia and phosphate of iron in a urinary calculus, which he subjected to analysis.

6. Magnesia and iron.

[7.] Silica, mixed with phosphate of lime, and occuring in calculi of the mulberry species, has been detected in two urinary concretions only of 600, which were examined by

7. Silica.

Fourcroy and Vauquelin. These calculi were particularly hard in their texture.

8. Urea first detected by Brande.

[8.] The presence of urea in calculi was first ascertained experimentally by Brande. Fourcroy and Vauquelin, however, had previously suspected its existence in them. It may be obtained from the calculi which contain it, by digestion in water or alchohol, and subsequent evaporation.

9. Cistic oxide.

[9.] Dr. Wollaston has detected a peculiar substance in calculi, to which he has given the name of cistic oxide. A small calculus, entirely composed of this substance, was white, dense and brittle. It dissolved both in acids and in solutions of potash or soda, and formed, with either, crystallizable compounds. It was insoluble in water, alcohol or ether. When treated with nitric acid, it formed a solution, which was not pink-coloured, and from which the oxide might be precipitated by the addition of water. When distilled, it yielded carbonate of ammonia and oil; and the residue consisted of a small portion of phosphate of lime.

10. Animal matter.

[10.] All calculi contain more or less of an animal matter, which serves as a cement to keep together their other ingredients. This matter had been considered to be albumen, but the more probable opinion is, that it is some modification of mucus, derived from the bladder.

6. Having thus given short notices of the different substances heretofore discovered in calculi, it will be next proper to give the classification of these bodies, as devised by different chemists.

Classification of calculi by Fourcroy & Vauquelin contains 12 species.

7. By far the most complete classification of calculi is that pursued by Fourcroy and Vauquelin, founded upon the results of the examination of 600 urinary concretions. These chemists divide them into three genera and twelve species. The following is their arrangement:

GENUS I. Calculi composed of one ingredient.

Sp. 1. Calculi composed of uric acid.
Sp. 2. ———————————urate of ammonia.
Sp. 3. ———————————oxalate of lime.

GENUS II. Calculi composed of two ingredients.

Sp. 1. Uric acid and the phosphates in layers.
Sp. 2. Uric acid and the phosphates mixed.
Sp. 3. Urate of ammonia and the phosphates in layers.
Sp. 4. Urate of ammonia and the phosphates mixed.
Sp. 5. The phosphates mixed or in layers.
Sp. 6. Oxalate of lime and uric acid in layers.
Sp. 7. Oxalate of lime and the phosphates in layers.

GENUS III. Calculi containing more than two ingredients. CHAP. II.

Sp. 1. Uric acid or urate of ammonia, the phosphates and oxalate of lime.

Sp. 2. Uric acid, urate of ammonia, the phosphates and silica.

The following are the characters of these different species:

Sp. 1. *Uric acid.*—Colour that of wood, with various shades of red and yellow. Surface, usually smooth and polished. Texture, laminar and radiated, compact and fine. Specific gravity, from 1·276 to 1·786. Soluble in solutions of potash or soda, without emitting the odour of ammonia. This species is by far the most common of all. Of the 600 calculi examined by Fourcroy and Vauquelin, one in every four belonged to this species. First, or uric acid species.

Sp. 2. *Urate of ammonia.*—Colour brownish-white. Surface often crystallized. Texture laminar. Laminæ easily separable. Specific gravity, from 1·225 to 1·720. Soluble in hot water, especially if in the state of powder. Solution in potash or soda attended by the odour of ammonia. This is a very uncommon species. Brande considers the calculi belonging to it to be in fact composed of uric acid, urea and hydrochlorate of ammonia. Second species.

Sp. 3. *Oxalate of lime.*—Colour soot-brown. Surface covered with pointed or rounded protuberances, and hence called the *mulberry* species. Texture dense and hard, resembling ivory. When sawn asunder, emitting the odour of semen. Specific gravity, from 1·428 to 1·976. Insoluble in potash or soda, but soluble, with difficulty, in acids. When burnt, leaves a residue of carbonate of lime. This species occurs frequently. Third, or mulberry species.

Sp. 4. *Uric acid and the phosphates in layers.*—Surface white like chalk, or sparry and semitransparent, according as the exterior layer happens to consist of the phosphate of lime, or of the phosphate of magnesia. Often large. When cut asunder, a nucleus of uric acid presents. Specific gravity very variable. One in every fifty calculi may be considered as consisting of this species. Fourth species.

Sp. 5. *Uric acid and the phosphates mixed.*—This species is very variable in its appearance. Specific gravity from 1·213 to 1·739. Its proportional occurrence is about one in every forty calculi. Fifth species.

Sp. 6. *Urate of ammonia and the phosphates in layers.*—This species does not differ in external appearance from the fourth species; but when cut asunder, it presents a nucleus of urate of ammonia. It is not a common species. Sixth species.

Sp. 7. *Urate of ammonia and the phosphates mixed.*—This Seventh species.

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species resembles the fifth, but may be distinguished from it, by emitting the odour of ammonia when treated with potash. The calculi belonging to this species, are small and rather uncommon.

Eighth species.

Sp. 8. *The phosphates mixed or in layers.*—This species is white like chalk, friable, and soils the fingers like that substance. Texture laminar; laminæ easily separable. Thin layers of phosphate of magnesia-and-ammonia, sparry and semitransparent, often interspersed. Specific gravity from 1·138 to 1·471. Soluble in acids, but insoluble in potash or soda. It occurs in the proportion of one in fifteen of the calculi, examined by Fourcroy and Vauquelin.

Ninth species.

Sp. 9. *Oxalate of lime and uric acid in layers.*—This species occurs either composed of a nucleus of oxalate of lime, covered by a layer of uric acid, or of a calculus of the mulberry species, covered with a layer of the same acid. These varieties are easily manifested upon sawing the calculus in two. It occurs in the proportion of one in thirty.

Tenth species.

Sp. 10. *Oxalate of lime and the phosphates in layers.*—This species is characterized by a nucleus of oxalate of lime, covered with a coat of the phosphates. It agrees in external appearance with several of the species, but its peculiar nature is rendered obvious, when the calculi belonging to it are cut asunder. Next to the uric species, this kind occurs most frequently in urinary calculi; being in the proportion of one in five of those examined by Fourcroy and Vauquelin.

Eleventh species.

Sp. 11. *Uric acid or urate of ammonia, the phosphates, and oxalate of lime.*—Calculi of this species have a nucleus of oxalate of lime, covered by a layer of uric acid, urate of ammonia, or a mixture of both, with an external coat of the phosphates.

Twelfth species.

Sp. 12. *Uric acid, urate of ammonia, the phosphates and silica.*—Calculi belonging to this species have a nucleus, composed of silica and phosphate of lime, covered by a layer of uric acid and urate of ammonia, with an exterior coat of the phosphates. Calculi belonging to this species will resemble those of several other species. Their distinctive nature depends upon their internal arrangement. They are of very rare occurrence, four only having been heretofore observed.

Arrangement of Fourcroy and Vauquelin, very complete: that of Wollaston is more simple and

8. The arrangement of Fourcroy and Vauquelin of urinary calculi is certainly very complete and satisfactory. Having had the advantage of examining a larger number of these concretions than any other chemists, their opportunities were greater to observe the proportional occurrence of calculi chemically the same. In a practical point of view, however, so minute a division of calculi, as adopted by

these chemists, can hardly be deemed of advantage. The following arrangement by Dr. Wollaston, in this respect, answers much better. Calculi are divided by this chemist into

practical; dividing calculi into

I. *Uric calculi.*—Under this name, are included such calculi as are wholly or chiefly composed of uric acid. This species may be considered as corresponding with Fourcroy and Vauquelin's first species. Calculi belonging to it are completely soluble, or very nearly so, in solutions of pure potash or soda.

1. Uric calculi.

II. *Fusible calculi.*—This species includes such calculi as are composed chiefly of phosphate of lime, and phosphate of magnesia-and-ammonia. It may be considered as corresponding, perhaps, with the 4th, 5th, 6th, 7th, 10th, 11th and 12th species in the arrangement of Fourcroy and Vauquelin. The calculi belonging to it are distinguished by melting into an enamel before the blowpipe. They are completely soluble, or nearly so, in hydrochloric acid.

2. Fusible calculi.

III. *Mulberry calculi.*—Under this name are included by Dr. Wollaston, such calculi as are composed chiefly of oxalate of lime, or of oxalate of lime and phosphate of lime. This kind corresponds with the 3d, 10th and perhaps the 9th species of Fourcroy and Vauquelin's arrangement. They dissolve slowly, but completely or nearly so, in hydrochloric acid. When there is any residuum, it consists of uric acid.

3. Mulberry calculi.

IV. *Bone-earth calculi.*—Under this epithet are included by Dr. Wollaston, all calculi which are composed chiefly of phosphate of lime. This kind may be considered, perhaps, as corresponding with the 8th species in Fourcroy and Vauquelin's arrangement. These calculi are soluble in hydrochloric acid.

4. Bone-earth calculi.

9. By comparing the composition of urinary calculi with that of urine, it will be found, that all the ingredients of these concretions are present in this animal liquid, except oxalate of lime, phosphate of iron, and cistic oxide. The phosphate of iron is given on the authority of a single analysis, and is certainly an ingredient in calculi of very rare occurrence. Too little is known of the manner in which the constituents of cistic oxide are combined, to allow of a conjecture to be formed of the probable source of this peculiar substance. The oxalic acid found in calculi is probably formed from uric acid; for Brugnatelli has observed, that oxalic acid is instantaneously formed, when chlorine is passed through water holding uric acid in solution.

All the ingredients of calculi are found in urine, except oxalate of lime, phosphate of iron and cistic oxide.

10. As to the manner in which urinary calculi originate, it may be remarked, that, as far as observation has gone, it would appear that uric acid is formed in the kidneys. The

calculous granules, emitted by persons labouring under nephritic complaints, are found to consist of this acid. It is, therefore, probable, that uric calculi are not formed originally in the bladder; but, by descending from the kidneys yet of small size, become the nucleus of a future calculus in that viscus.

Calculi may be dissolved, out of the body, by solutions of alkaline bases or of acids, so weak as to be held in the mouth without inconvenience.

11. Fourcroy and Vauquelin have made a number of experiments, in order to ascertain how far it would be practicable to dissolve urinary calculi, by injecting solvents through the urethra. As far as solvents are concerned, these concretions may be arranged under three heads: 1. Calculi composed of uric acid or of urate of ammonia; 2. Those composed of the phosphates; and 3. Those composed of oxalate of lime. Solutions of pure potash or soda, so weak as that they may be held in the mouth without inconvenience and swallowed without pain, dissolve readily calculi of the first kind. Nitric or hydrochloric acid, so much diluted as to cause no inconvenience when swallowed, dissolves very quickly calculi of the second kind. The third kind are of more difficult solution. Such calculi, however, dissolve slowly in nitric acid, and in solutions of the carbonates of potash or of soda, so much diluted as not to irritate the bladder.

These solvents, proposed to be injected into the bladder.

12. It is proposed by these chemists to inject the solvent, at the blood heat, into the bladder, previously emptied of urine. In order to ascertain the proper solvent, they proposed first to inject a weak solution of potash, the solvent proper for calculi of the most frequent occurrence. After the injection has remained for half an hour or longer, it is to be discharged, filtered, and tested by means of hydrochloric acid. If any uric acid has been dissolved, it will be thrown down by this test in the form of a white powder. If no indication of the presence of uric acid exists, and that after the solution of potash has been used for several days; it is next proper to proceed as if the stone present was composed of the phosphates, and accordingly to inject hydrochloric acid, diluted to the proper degree. Should the stone prove to be composed of the phosphates, then by testing the solvent, after being returned from the bladder, by ammonia, phosphate of lime will precipitate. If this should not be the case, the last resort is to proceed in the manner proper for the mulberry calculus, and inject a properly diluted nitric acid. In case any of the solvents succeed for some time and afterwards cease to have effect, they should be changed for others, until the proper solvent may be hit upon, to suit the chemical nature of the particular coat of the concretion which may present exteriorly.

SECTION VII.

OF GOUTY CALCULI.

Gouty calculi consist of urate of soda.

1. It is well known, that certain concretions are formed in the joints of persons long subject to the gout, which, from their white colour and softness, are generally called chalk stones. These concretions were first analyzed in 1797 by Dr. Wollaston, who found them composed of urate of soda.

Having thus finished the consideration of all the parts and products of the human body, which have been observed with any degree of accuracy; it may conduce to give a correct comparative idea of their chemical nature, to present a synoptical view of their constituents. Such a view is attempted to be given in the annexed table.

A. Extractive is excluded from the enumeration of the ingredients of muscle and marrow, as not being sufficiently characterized.

B. The true skin is composed of gelatin, and the cuticle of modified albumen.

C. The reader will recollect, that chyle contains a substance, considered as intermediate between albumen and fibrin.

D. To understand the ultimate constituents of blood as given in the table, it is necessary to recollect, that phosphorus, calcium, magnesium and iron are considered as constituents of the colouring matter of this liquid.

E. The colouring matter of the blood is not, strictly speaking, an ingredient in the lens, but a matter having all the properties of this substance, except colour: see page 556.

F. It is the curdy part of milk which is considered as albumen, although somewhat different in its properties. The analysis of milk given in the table is to be considered as of cows' milk.

G. Pus, strictly speaking, does not contain albumen, but is made up principally of a substance, a good deal allied to albumen in properties.

H. If Chevreul's opinion should prove to be correct, then adipocire is not a constituent in gall-stones; but the substance, taken for adipocire, is a peculiar one, which Chevreul proposes to call cholesterine.

OF THE PR

CHAPTER III.

REFLECTIONS UPON THE CHEMICAL CONSTITUTION OF THE HUMAN BODY.

1. By the assistance of the table just given, the reader will be enabled to enter into a general examination of human animal constituents.

2. By far the greater part of the matter which composes the human body may be referred to the general heads of bone, of muscle, of membrane, tendon, cartilage and ligament, of fat, and of blood. It is evident, therefore, that gelatin, albumen, fibrin, oil, and phosphate of lime are the proximate constituents of the human body, which compose nearly the whole of its substance, whether solid, soft or liquid. Gelatin occurs in bone, though not in large amount; it constitutes the whole of membrane and tendon, and forms a part of cartilage and ligament. Albumen enters largely into the composition of bone, of cartilage and ligament, and of blood: it occurs in small amount in muscle, while it is absent in membrane and tendon. Fibrin is the characteristic ingredient of muscle and of blood; and is no where else to be found, unless the fibrous matter, detected in sinovia by Margueron, be considered as this substance. Muscle and blood are so very analogous in constituents, as to justify the remark, so frequently made, that muscle is nothing else than solid blood. Oil exists in bone, and composes the whole of the adipose membrane; but is absent in the other principal parts of the animal structure. Phosphate of lime, as a characteristic ingredient, is peculiar to bone.

Chief parts of the body are bone, muscle, tendon and cartilage, fat & blood: hence its chief proximate constituents are gelatin, albumen, fibrin, oil, and phosphate of lime.

3. Besides being present in some of the principal parts of the human body already mentioned, gelatin, somewhat modified, forms the whole of the true skin, and a part of marrow and hair; while it occurs in small quantity in sweat and in urine, according to some experiments.

4. Albumen constitutes a very important ingredient in most of the subordinate parts of the body. Somewhat modified, it constitutes the whole of nail and of cuticle, and a part of brain, of marrow, of hair, of chyle, of feces, of saliva, of bile, of the mucus of the nose, of the cerumen of the ear, of sinovia, of urine, of milk in the form of curd, of all the serous liquids, and of pus.

5. Fibrin must be considered as peculiar to muscle and to blood.

Fibrin is peculiar to muscle and blood.

6. Colouring matter of the blood is certainly a very singular animal constituent; more especially if Berzelius's

opinion should prove to be correct, that phosphorus, calcium, magnesium, and iron are constituents in it, in no particular state of combination. As to what composes the great bulk of this animal substance, there is some discrepancy of opinion. The most probable supposition perhaps is, that it is some modification of fibrin. The singular substance analogous to the colouring matter of the blood, found by Berzelius in the crystalline lens, requires further investigation.

7. It would be of considerable importance to ascertain the exact differences between vegetable and animal mucus. If they are really distinct substances, to avoid confusion they should have different names. Chemists have distinguished a vegetable and an animal jelly, a vegetable and an animal extractive, a vegetable and an animal fibrin. A solution of vegetable jelly is called gelatinous, as well as a solution of animal jelly or gelatin. This want of precision leads to error. Extractive is a very indefinite term, and means different things as used by different chemists. The term mucilage is frequently employed without precision; it sometimes means a solution of gum, and sometimes a solution of mucus. The solution of the latter might be distinguished by the adjective *mucous*.

8. It may be considered as very doubtful whether the peculiar nature of osmazome has been established.

Picromel is characteristic of bile.

9. Picromel may be considered as the characteristic ingredient in bile. It enters into the constitution of gall-stones. It composes also a very large portion of the feces. The opinion of the excrementitious nature of the bile is not without support from the latter fact.

10. Certain gall-stones have been considered as composed entirely of adipocire. This opinion has been lately called in question by Chevreul, who considers that the gall-stones, previously supposed to consist of this substance, are in fact made up of a form of matter not previously recognized, which he proposes to call cholesterine.

Urea is characteristic of urine.

11. Urea is the characteristic ingredient of urine. This secretion is very little else than a solution of urea in water. This animal substance is occasionally found as a constituent of urinary concretions.

12. Cistic oxide is a peculiar animal substance, which occurs as a very rare ingredient in urinary concretions.

Sugar of milk, found in chyle as well as in milk.

13. Sugar of milk was first discovered in milk. Its discovery in chyle strengthens the analogy observed between these animal liquids, which have a number of other constituents in common. A portion of iron is detected in both.

14. Oily substances, varying considerably in nature, are to be found in the various parts and products of the body. Be-

sides the fixed oil, which constitutes the fat so universally found, filling up interstices and giving an uniform figure to the body and limbs, there are oils peculiar to particular parts. Marrow, according to Berzelius, contains a peculiar fixed oil. Human milk contains a peculiar oil, which, however, is not concrete, as that which may be extracted from cows' milk. Brain and hair are found to contain peculiar coloured oils. Cerumen contains a peculiar oil, and so also does sweat. Bone possesses an oily part, which is not strictly speaking a part of the bone.

Phosphorus exists in brain; and

15. According to Vauquelin's analysis of brain, phosphorus enters into it as a constituent. It is difficult to understand, how such a substance could be present, without entering into some particular combination.

uncombined sulphur in brain, hair and urine.

16. Uncombined sulphur has been detected as a constituent in brain, in hair, and in urine. It may be worthy of inquiry, whether the sulphur, detected in these substances, is derived from the albumen, which is one of their constituents. It is certain, that albumen cannot be obtained entirely free from sulphur: but, how far this fact may prove Berzelius to be correct in asserting, that sulphur is an essential ingredient in albumen, remains yet to be demonstrated. However this may be, it is certain, that uncombined sulphur has not been detected in any animal substance, in which albumen has not been found. Phosphorus and sulphur are the only undecompounded substances, in an uncombined state, which occur in animal bodies. Hence they are enumerated in the table, both as proximate and as ultimate constituents.

Water, a very important animal constituent.

17. Water must be considered as a very important constituent of animal bodies. It causes the liquidity of all those parts of animals, which require to have this state, in order to answer the purposes for which they are intended. It is the only menstruum employed by nature. It must not, however, be considered as unimportant in itself; as it consists of two principles, as universally present in animal matter, as any others. It may, therefore, be considered as very materially concerned in nutrition.

Soda is found in a number of animal substances.

18. Soda is an ingredient in bone, in blood, in feces, in saliva, in bile, in tears, in the mucus of the nose, in cerumen, in the aqueous and vitreous humours of the eye, and in sinovia. The portion of this alkaline base, which exists in bone and blood, is very small. That found in feces may be considered as derived from the bile. It occurs in tears, on account perhaps of its detergent property. The mucus of the nose probably derives its soda from the tears, which are constantly passing into this cavity. It may be pro-

per to remark here, that Dr. Pearson, contrary to the received opinion, considers potash, and not soda, to be the alkaline base present in the animal fluids.

19. Uncombined lime occurs in bone, in bile, and in the liquor of dropsy; but in very minute quantity in each. This ingredient cannot be considered of importance in animal substances.

20. Uncombined magnesia occurs as a constituent in one class only of the animal substances, mentioned in the table; namely, urinary concretions. But one calculus has been found heretofore to contain uncombined magnesia.

21. Silica has been found in three animal substances only; namely, hair, urine, and urinary concretions. It occurs in very minute proportion in hair and urine. In concretions of the bladder, it is a rare ingredient.

Iron, detected in chyle; iron and manganese, in hair.

22. Traces of uncombined iron, or of oxidized iron, have been detected in chyle. The same metal, together with manganese, has been detected in hair.

Chloride of potassium and of sodium, in what animal substances present.

23. Chloride of potassium occurs, in small amount, in blood, in saliva, in the mucus of the nose, in the aqueous and vitreous humours, in the crystalline lens, and in milk; but whether as an essential ingredient, and in an invariable proportion, has not been correctly ascertained. Chloride of sodium occurs in muscle, in hair, in chyle, in blood, in saliva, in the gastric secretion, in bile, in tears, in the mucus of the nose, in the aqueous and vitreous humours, in the crystalline lens, in the liquor of the pericardium, in sinovia, in urine, in the liquor of the amnios, in the liquor of dropsy, and in the liquor of blisters. Thus it appears, that this chloride is present in every animal substance, in which the chloride of potassium is found, except milk; and in a great number of substances, in which it exists alone. This very general occurrence of chloride of sodium, in small proportion in the animal fluids, favours the belief, that this chloride is rather an accidental than an essential constituent, more especially as it is introduced, into the stomach, so universally with the food.

Uric acid, a chief ingredient in calculi; but a subordinate one in urine.

24. Uric acid occurs in small amount in urine, where urea is abundant; but as a very principal ingredient in urinary concretions, in which urea is a rare ingredient. It has considerable analogy to urea in some of its properties; and the inverse proportion, in which these two substances occur in urine and in urinary calculi, favours the opinion, that urea is convertible into uric acid, and by undergoing this conversion gives rise to the formation of uric calculi. Besides uric acid, several other uncombined acids are present in animal substances; as carbonic acid in bone, urine, and sweat;

benzoic acid in urine only; and lactic acid in urine, sweat, and milk.

Salts present in animal substances.

25. Of salts, hydrochlorate (muriate) of ammonia occurs in urine and in urinary calculi, and no where else; phosphate of ammonia, in brain and in urine; lactate of ammonia and the sulphates of potash and of soda, in urine only; carbonate of potash, in expectorated matter; phosphate and acetate of potash, in milk only; urate of soda, as peculiar to gouty concretions; and carbonate of soda, in semen, in the liquor of the amnios, and in the liquor of blisters. The phosphate of soda occurs more generally distributed than any of the salts just named. It is found in muscle, in brain, in blood, in bile, in tears, in the mucus of the nose, and in urine. Lactate of soda occurs in muscle, in blood, in saliva, and in the mucus of the nose. Traces of sulphate of lime have been detected in brain and in hair, but in no other animal substances; and of carbonate of lime, in hair and the liquor of the amnios. Phosphate of lime has already been mentioned as constituting the basis of bone. It occurs also in nail, in muscle, in brain, in hair, in chyle, in bile, in tears, in cerumen, in sinovia, in urine, in semen, in milk, in the liquor of the amnios, in the liquor of blisters, and as a common ingredient in urinary concretions. Thus this salt, besides forming the greater part of bone is found distributed, in small quantity, in many animal substances both solid and liquid. Oxalate of lime occurs as an ingredient of urinary calculi only. Hydrofluate (fluate) of lime is found as a constituent in bone, and, in very minute proportion, in urine. Phosphate of magnesia is present in bone, in urine, and in milk; while the ammonio-phosphate is found only in urinary concretions. Oxidized iron has been found in the state of phosphate in a calculus, and in the state of lactate in milk.

Phosphate of lime, characteristic of bone.

Oxalate of lime found only in urinary calculi.

Acids found in animals, uncombined or otherwise.

26. The uncombined acids have been noticed already, as being the uric, carbonic, benzoic and lactic acids. All these acids, except the benzoic, occur also in saline combinations. Besides these acids, there are found, always in a combined state, the hydrochloric, sulphuric, phosphoric, oxalic, acetic, and hydrofluoric (fluoric) acids: so that the total number of acids found in animal substances is ten. Uric acid is found combined only with soda, in the form of gouty concretions; carbonic acid, only with potash, soda and lime; lactic acid, with ammonia, soda and oxidized iron. Uric and lactic acids are exclusively of animal origin. Hydrochloric acid is found combined with ammonia only; sulphuric acid, with potash, soda and lime. Phosphoric acid exists combined with ammonia, potash, soda, magnesia, oxidized iron, but particularly with lime. This acid is by far the most abundant in animal substances. The oxalic acid oc-

Phosphoric acid, most

curs in combination with lime, only in certain species of urinary calculi. The acetic acid combined with potash has been detected in milk by Berzelius alone. The hydrofluoric (fluoric) acid is a very rare constituent in animal substances, and is always combined with lime.

abundantly present of the acids in animals.

Lime, the most abundant salifiable base.

27. Of the alkaline salifiable bases, lime is beyond all comparison the most abundant in animal substances. Next to it comes soda, then potash, then magnesia, and lastly ammonia, the three latter being in very small amount. The only earthy base heretofore detected in animal substances is silica, and that in very small proportion.

Oxygen, azote, hydrogen and carbon, the most abundant ultimate constituents.

28. As the ultimate constituents of animal substances, it is perceived by the table, that oxygen, azote, hydrogen and carbon comprise nearly their whole amount. Phosphorus and calcium are the next most abundant, being ultimate constituents of bone. Chlorine occurs in combination with potassium and sodium; and combined with hydrogen forming hydrochloric acid. This supporter is present in small amount in nearly two-thirds of all animal substances. Fluorine is given in the table, on the supposition, that the radical of the hydrofluoric (fluoric) acid will prove to be some new form of matter. Sulphur, as an ultimate constituent, occurs, in minute quantities only, in animal substances. Potassium, sodium, magnesium and silicum occur nearly in the same relative proportions as potash, soda, magnesia, and silica, of which they are the radicals. Excepting the alkaline and earthy metals, iron and manganese are the only metallic bodies found in animals. Now it will be recollected, that these same metals alone were detected in vegetables. It can hardly be supposed possible, that animals could contain a constituent, which did not exist in vegetables; as the former, either directly or indirectly, draw all their nutritive materials from the latter.

CHAPTER IV.

OF ANIMAL FUNCTIONS ELUCIDATED BY CHEMISTRY.

A great deal of interesting matter might be arranged under this title; but the proposed limits of the present work will only permit of giving a sketch of what is known on respiration, and some reflections on secretion and assimilation

SECTION I.

OF RESPIRATION.

1. All animals are furnished with some contrivance or other for exposing their blood to the influence of the air. This remark is applicable to fish, to insects and to worms, as well as to the more perfect animals. All animals subject their blood to the action of air.

2. The contrivance, in man and in the warm blooded animals, consists in a cavity, capable of being increased in size by the action of muscles, and containing vascular bags, called the lungs. These bags are so arranged, as that the communication of the external air, with the cavity, must take place through apertures in them, and in no other way. It consequently happens, that when the cavity is enlarged by muscular action, the external air presses into the bags; but when it is rendered smaller, the contained air is pressed out; and it is on this mechanical principle, that breathing is carried on. Mechanism of respiration described.

3. What purpose, then, does this exposure of the blood to the influence of atmospheric air effect? This question can be answered only by investigating the changes, which are consequent to it, upon the respired air and the blood; and accordingly these objects of research have engaged the attention of numerous chemists and physiologists. In respiration, the air respired and the blood suffer changes.

4. Common air, which has been respired, is altered in the following particulars: a portion of oxygen has disappeared, a quantity of carbonic acid has been formed, and it is loaded with water in a state of vapour.

5. Taking the general results of experimenters on the subject, it will be found, that the bulk of the carbonic acid, formed during respiration, is very nearly, if not precisely, equal to that of the oxygen which has disappeared. Now it is well known, that oxygen, when changed into carbonic acid, does not alter its bulk; hence the presumption is, that the whole of the oxygen, which disappears as uncombined oxygen, enters into the composition of the carbonic acid emitted. This is a more probable opinion than the one which supposes, that the oxygen which disappears has combined permanently with the blood, and that the carbonic acid evolved had previously existed in this animal liquid ready formed.

6. In this way, two of the changes which take place in air by respiration, namely the disappearance of uncombined oxygen and the evolution of carbonic acid, are explained. It is only uncombined oxygen which has disappeared; for the oxygen, in the combined state, is still present in the carbonic acid formed. From this it is evident, that air in re-

spiration loses nothing, but gains a quantity of carbon; and this carbon is separated from the blood. The fair conclusion therefore is, that the principal intention of respiration is to eliminate carbon from the blood.

Respiration separates carbon from the blood.

7. The third alteration, which takes place, in respired air, is its being loaded with vapour. This vapour cannot be considered as formed in the lungs, as is the case with the carbonic acid; since all the oxygen which disappears goes to the formation of this acid. It is, therefore, probable, that water is given out by the vessels of the lungs, and becomes dissolved in the respired air on account of its increase of temperature.

8. The quantity of carbonic acid, emitted by the lungs, is found to vary at different times in the 24 hours. It has been ascertained by Dr. Prout, that the quantity of this acid formed is greatest at noon and least at midnight.

Average quantity of carbon emitted is three-fourths of a pound in 24 hours.

9. Several calculations have been made to ascertain the probable quantity of carbonic acid emitted by respiration in the 24 hours. Dr. Thomson considers the average to be 40,000 cubic inches, a quantity which contains about three-quarters of a pound avoirdupois of solid carbon; and this estimation does not differ much from that made by Allen and Pepys, as deduced from their experiments. Under particular circumstances, however, the usual quantity of carbonic acid formed is lessened. Thus it has been ascertained by Dr. Prout and Dr. A. Fyfe, that the carbonic acid, produced by respiration, is diminished by the use of spirituous and fermented liquors, by the action of mercury or of nitric acid, and by a vegetable diet.

10. The amount of aqueous vapour, emitted in the twenty-four hours, is no doubt exceedingly various in different individuals, and under different circumstances. From some trials to ascertain this point, made upon himself, Dr. Thomson found, that nearly nineteen ounces was the quantity emitted by his lungs for that space of time.

Arterial differs in colour from venous blood.

11. It had been observed at a very early period by physiologists, that the blood, which flows in the veins, is different in appearance from that contained in the arteries. Venous blood has a dark purple colour, while arterial blood is of a bright scarlet. Now it is well known, that blood in the venous state is returned, from all parts of the body, into the heart, on its right side, whence it passes into the lungs by the ramifications of the pulmonary artery, and is ultimately received again into this organ, on its left side, from the pulmonary veins. But by the time it has arrived on this side, it is no longer of a dark colour, but has assumed a bright scarlet one, and the arterial character. It therefore appears,

that this change in blood takes place exclusively in the lungs; and it is fair to conclude, that it depends entirely upon the influence of air in respiration. This influence has already been stated to consist in the separation of carbon.

Venous becomes arterial blood, in the lungs, by being decarbonized.

12. An absolute chemical difference has never been made out, by experiment, between arterial and venous blood; but it is fairly inferable from the facts, just stated. How then, it may be asked, does arterial blood acquire a redundancy of carbon, whereby it becomes changed into venous blood? To this it may be answered, that the redundancy propably occurs, in the course of the circulation, in consequence of the abstraction, in secretory processes, of a larger proportional quantity of all the constituents of blood except carbon, than of the carbon itself. Whether this conjecture be well founded, could only be ascertained by noticing, if all the constituents of blood, except carbon, be present in larger amount in the secretions, taken collectively, than carbon itself.

Probable cause of redundancy of carbon in venous blood suggested.

13. Respiration has as yet been considered as carried on by atmospheric air, the only gaseous fluid which supports the process properly; but, besides this fluid, there are several other gases, which may be respired, but which sooner or later destroy life.

Atmospheric air, the only air fit to maintain the respiratory function; others are respirable, but ultimately destroy life.

14. One set of these respirable gases, which do not support life, seem to act negatively, by depriving an animal of the air, proper to carry on natural respiration. In this way azote and hydrogen are supposed to destroy life. Another set of respirable gases appear to be unfit for respiration, in consequence of some positive effect which they produce on the blood. In this way, the bihydroguret of carbon (carburetted hydrogen), hydrosulphuric acid (sulphuretted hydrogen), and carbonic oxide are supposed to act. A third set may be breathed for some time, without much inconvenience, but would unquestionably sooner or later produce death. Of this kind are the protoxide of azote (nitrous oxide), and oxygen gas. These gases would appear to be improper for supporting life, on account of the too great stimulus, which they produce. The protoxide of azote is known to give rise to a very strong degree of stimulation, and oxygen gas appears to require some other gas to be mixed with it, for the purpose of dilution. Common air, which is the only proper gaseous fluid for respiration, may be considered as oxygen gas diluted by azote. Oxygen, diluted by hydrogen to the same degree, carries on respiration without inconvenience; and the formation of carbonic acid goes on as regularly as when common air is the respired fluid. There are, however, these differences when oxygen and hydrogen are employed, that

a portion of the oxygen disappears, and azote is found in its place, and the animal, breathing the mixture, has a tendency to sleep.

Certain gases cannot be drawn into the lungs.

15. Some gases cannot be drawn into the lungs, the glottis closing spasmodically whenever the attempt is made. These have been called unrespirable gases. To this set belong ammoniacal gas, carbonic acid gas, and in short all the acid gases.

Effects of different gases on venous blood.

16. It has already been stated, that venous blood becomes arterial, by passing through the lungs. Now it has been ascertained, that venous blood, out of the body, assumes the colour of arterial blood, when exposed to some of the gases. Venous blood, subjected to the influence of pure oxygen gas confined over it, instantly assumes a scarlet colour. The same change in this kind of blood is effected by common air, but not so rapidly. In both cases, the bulk of the air remains very nearly, if not absolutely, the same; but the air itself is changed, a portion of its oxygen being converted into carbonic acid. Hence it would appear, that the same changes take place in venous blood, when exposed to common air or oxygen gas, out of the body, as when in the lungs.

17. Venous blood, exposed to the action of deutoxide of azote (nitrous gas), becomes of a deep purple colour. Under similar circumstances, the protoxide of azote (nitrous oxide) changes its colour to a bright purple. In both cases, a portion of the gases is absorbed. When exposed to the action of carbonic acid, it becomes much darker, and a small portion of the gas is absorbed. Bihydroguret of carbon changes it to a fine red colour, a shade deeper than that produced by oxygen gas.

Effects of different gases on arterial blood.

18. On the other hand, arterial blood, exposed to the action of azote, hydrogen or carbonic acid confined over it, assumes the colour of venous blood. This same change takes place in it, however, when placed in vacuo. Hence it must be considered as independent of the action of any external agent. This change, in arterial blood, is not prevented even by exposure to the action of oxygen gas, although it is very considerably retarded.

Animal heat, attributed to respiration.

19. Animal heat is usually attributed, as an effect, to respiration, although there are many circumstances unfavourable to this opinion. The fact, however, is a striking one, that the heat of different animals is greater, in proportion as their apparatus for breathing is on a larger scale.

Crawford's theory of animal heat is founded up-

20. By far the most ingenious theory of animal heat, deduced from the respiratory process, is that of Dr. Crawford. Dr. Black had considered, that animal heat is produced in the lungs, in consequence of the conversion of

latent into sensible heat. Upon such a supposition, however, the heat could not be uniform all over the body. Dr. Crawford gets over this difficulty, by supposing, that part of the heat of the respired air becomes latent in the blood, after it has assumed the arterial character. This transfer, he considers to take place, in consequence of a simultaneous alteration in the specific caloric of the air of respiration and of the blood; that of the air being decreased, while that of the blood is proportionably increased. In this way, the caloric, derived from the air, and which would otherwise have been sensible or distributable, is instantly transferred to the blood, to fill up its increased capacity. Now Dr. Crawford found, that the specific caloric of oxygen gas and arterial blood on the one hand, was greater than that of carbonic acid and venous blood on the other; just what ought to be the case, if the theory which he advocated were correct. Hence it must follow, that, in the course of the circulation, as the arterial blood is gradually assuming the venous character, in consequence of those actions which are implied in the functions of secretion and nutrition, it is at the same time suffering a decrease in specific caloric or capacity, and must be, in the same proportion, evolving distributable heat.

CHAP. IV. On a difference in the specific heat of arterial and venous blood.

21. Although subsequent experiments have confirmed the conclusions of the difference in specific caloric of carbonic acid and oxygen gas, and of venous and arterial blood; yet they are far from making it as great as was calculated by Crawford. From the experiments of Delaroche and Berard, it appears, that the specific caloric of carbonic acid is to that of oxygen gas, as 0·8280 to 0·8848; while those of Dr. Davy determine the relative specific calorics of venous and arterial blood to be as 0·903 to 0·913. These differences are so small, that they would hardly be considered as sufficient to account for all the animal heat on Crawford's theory; but, when it is recollected, that the whole of the blood of the body makes a complete revolution in less than three minutes,* when the fact is adverted to, that arterial blood is undergoing the change into venous blood in all parts of the body at the same moment, these differences in specific caloric may not perhaps be esteemed too minute to account for the production of animal heat.

This difference is not so great as Crawford supposed.

22. It appears by some late experiments, performed by Brodie, that, when respiration is carried on artificially in a

Brodie's experiments seem unfavourable to the supposition that respiration causes animal heat.

* This calculation of the time, which the whole of the blood of the body takes to pass through the heart, is founded upon the suppositions, that the amount of blood in the adult is 30 pounds, that the average number of pulsations in a minute is 75, and that the quantity of blood expelled at each pulsation is two and a half ounces.

decapitated animal, the usual proportion of carbonic acid continues to be formed; and, notwithstanding, instead of the animal heat being preserved under such circumstances, it is actually lost quicker than it would be in an animal recently killed. To judge how far these results invalidate the conclusions of Crawford, it would be necessary to inquire, whether, in Brodie's experiments, the blood returned to the lungs in the arterial or venous state. If it returned in the venous state, it would seem to prove, that the blood had undergone those changes, which are consequent to its employment in secretion and nutrition; but it is not probable that it could be thus employed in a decapitated animal. But if it be supposed, that the blood, in such cases, undergoes little or no change in the course of the circulation, is not the loss of animal heat, just what ought to take place according to Crawford's theory, which considers that the animal temperature is kept up, as a consequence of the gradual conversion of arterial into venous blood. On the other hand, if the blood goes the round of the circulation without losing its arterial character, whence is the carbonic acid derived, which Brodie found to be invariably formed in his experiments.

Respiration is probably the principal cause of animal heat, and is assisted by other causes.

23. Upon the whole, perhaps the most correct opinion on the subject of animal heat is to suppose, that the principal cause of it is respiration, by effecting upon the blood such a change, as that, upon another change during the circulation, it will be giving out, gradually, distributable heat; greatly assisted, however, by the vital actions, such as secretion, digestion, muscular action, and, in short, by every process implying motion, which occurs in the living body.

SECTION II.

OF SECRETION AND ASSIMILATION.

Food undergoes certain changes before it becomes blood.

1. The different parts of the animal system are constantly undergoing a waste, which is supplied by materials taken into the stomach. These materials undergo a suite of changes in the processes of digestion and chylification; and the product is thrown into the blood vessels, where it becomes perfect blood. Into this complex liquid, all the nutritious matter, taken into the stomach, must be converted, before one particle of it can be employed to supply the exigencies of the living animal; for it is from blood alone, that all the parts of the body, whether solid or liquid, are formed. Now the action, by which certain liquids are sepa-

Blood is the material, out of which every animal part is formed.

rated from the blood, is called secretion; and the action, by which the same animal liquid is converted into the organized parts of the body, is called assimilation. Blood being, then, the material from which all the parts of the body are formed, it follows, as a necessary consequence, that this liquid must contain all the elementary principles of animal substances.

Secretions are formed to be used, or to be thrown off.

2. The secretory action takes place in the body, apparently with two views: 1. to form from the blood a substance to be applied to some useful purpose; and 2. to separate something from the same liquid, which is either noxious or useless, and which is to be thrown off from the body entirely.

Excrementitious secretions are urine, sweat, and carbon.

3. All the secretions of the human body may be considered as formed with the first view; except that of urine in the kidneys, of sweat by the skin, and, without perhaps resorting to any very strained analogy, of carbon and water by the lungs. It may be considered doubtful, whether bile is secreted with the first or second view; but the latter supposition is the most probable.

All the ultimate constituents of the useful secretions are in blood, but not their proximate constituents.

4. Considering then the useful secretions, the question arises, are the constituents of these substances to be found in the blood. The answer is yes, so far as it regards ultimate constitutents. Indeed most of their proximate constituents are present in this liquid, but not all. Thus, mucus is present in saliva, tears, the mucus of the nose, the liquor of the pericardium, and in semen, but not in blood. Sugar of milk is present in chyle and in milk, but is absent in blood. These facts are sufficient to demonstrate to the physiologist, that, during secretion, substances already formed are not merely separated; but that the blood actually suffers decompositions and recompositions in the process.

Assimilation forms organized parts.

5. In the process of assimilation, a great many very dissimilar organized substances are formed from the blood. The principal of these are muscle and bone. Blood contains, in abundance, the substance, which is the characteristic ingredient of muscle, namely fibrin; hence the formation of the latter from the former may be very well explained. But the principal ingredient in bone is phosphate of lime; how then does the blood furnish this salt, which does not exist ready formed in it. It is indeed true, that phosphoric acid exists in blood, and so also does the radical of lime according to Berzelius, as a constituent in its colouring matter. Accordingly, it may be said, that the phosphate is composed in the act of forming or repairing the bone; or it may be contended, that its quantity in the blood, sufficient to renew the

daily waste of bone, is too small to be detected in the mass of this liquid.

Some of the ultimate constituents of animal substances are not found in blood.

6. By viewing the table given of animal substances, it will be seen, that blood contains all the ultimate constituents found in them, except fluorine, silicum and manganese. The question, therefore, arises, how can blood form bone which contains fluorine, or hair which contains silicum and manganese. Are these facts to warrant the conclusion, that neither fluorine, silicum, nor manganese are simple substances; or should they not rather be explained by supposing, that these bodies exist in too minute quantities in the blood to be detected.

Blood requires, not only to be renewed, but the proportions of its constituents, re-adjusted; and this re-adjustment is effected probably by the secretions of waste.

7. It is reasonable to suppose, that the blood, suffering so many abstractions of its constituents in secretion and assimilation, would require, not only to be renewed constantly by new accessions of matter, but also to have thrown off from it particular constituents, which might be left in excess by a too abundant abstraction of others. And this, indeed, appears to be the fact; and to separate such redundant constituents, would appear to be the purpose of the several secretory actions, which eliminate substances to be thrown out of the body.

Separation of carbon in the lungs is analogous to secretion.

8. The substances, which it is here proposed to consider as secretions of waste, are carbon emitted from the lungs, urine, sweat, and the bile. The process, by which carbon is separated from the blood in the lungs, is very much like secretion. Venous blood is carried by a set of vessels to all parts of a spongy substance, and, at their ultimate ramifications, throws off a substance, which passes out through the branches of the bronchiæ, as through so many excretory ducts. There is indeed this difference, that an agent, in the form of atmospheric air, must pass down these ducts to assist in the elimination, by combining with the substance to be separated. But whether the process, by which carbon is separated in the lungs, be considered secretory or not, it nevertheless appears certain, that the chief purpose of respiration is to separate an excess of this combustible from the blood.

Redundant azote appears to be abstracted from the blood by the urine.

9. The secretory office of the kidneys may be considered as the chief means, which nature employs to discharge redundant azote from the blood. The urine is made up principally of urea, which animal substance, according to Dr. Prout, contains nearly half its weight of azote. From this statement it is evident, how very large a proportion of azote must be contained in this secretion. Besides azote, urea contains oxygen, hydrogen and carbon. Whether all the constituents of this animal substance are liable to become

redundant in the blood, in proportions suited to its formation, cannot, perhaps, be ascertained; but should this be the fact, then their greater or less redundancy, occurring in such proportions, may be removed by a more or less abundant formation of urea.

Urine, from its nature, furnishes very obvious outlets for redundant constituents in the blood.

10. The means of re-establishing the proper proportional amount, in the different constituents of the blood, may be clearly inferred from the various ingredients of urine. If it be necessary to separate a large quantity of oxygen and hydrogen, it may be supposed, that water is compounded in the kidneys. A larger quantity of carbon than exists in urea may be separated by the production of a larger or smaller amount of carbonic, benzoic, or lactic acid; but for the separation of this substance, the lungs may be considered as the appropriate organs. Any proportional excess in the other constituents of blood may be separated as component parts of the different salts, which occur in urine in various amounts. So that it is probable, that the varying exigencies of the blood, with regard to redundant constituents, is the true cause of the varying nature of the urine.

11. All the ultimate constituents of blood are found in urine, except iron. This metal, considered as a component part of the colouring matter of the blood, could not reasonably be expected to exist in the urine; as it is not probable, that this matter requires to undergo any decomposition in the renovation of the blood. On the other hand, fluorine and silicum occur as ultimate constituents of urine, though not to be found in the blood. As, however, these substances occur in very minute proportion, may it not reasonably be supposed, that they exist also in the blood, although in too minute a quantity to be detected.

Sweat separates redundant constituents from the blood.

12. The action which separates matter from the body through the skin, whether this matter occurs as sweat or insensible perspiration, may be enumerated among the means, by which the blood is purified from redundant constituents. As far as the investigations of chemists and physiologists have extended, there appears to be established a very close analogy, in function, between the lungs in respiration, and the skin in perspiration. Both organs are constantly emitting water in a state of vapour, and carbon in the form of carbonic acid. The sympathy between the lungs and skin is well known to every one. Whenever the skin is interrupted in its function, the lungs suffer. This is usually accounted for by supposing, that the aqueous fluids, which should pass through the skin, are thrown upon the lungs; but may not the suspension of the separation of carbon through the skin, in cases of suppressed perspiration, be the

Office of the skin and of the lungs appears to be the same; hence the sympathy of these organs.

principal cause of the inconvenience, suffered by the pulmonary organs. It is well known, that the kidneys perform the vicarious office of the separation of aqueous fluid, when such fluid is prevented from passing through the skin; now, when carbon is retained as a consequence of suppressed perspiration, does not the coincidence in office between the skin and the lungs make it probable, that these organs may excrete a superabundant quantity of this combustible, as long as the suppression by the skin may continue. It is a well known law, which the Author of nature has impressed upon the animal economy, that the different organs, like kind friends, assist each other in the performance of their respective functions, when, from disease or otherwise, any one of them may be unable to perform its own.

The intention of bile still continues doubtful.

13. Bile has been enumerated as a substance, which is separated from the blood as useless; but this point is far from being settled. Adopting, however, the supposition that it is separated for the sake of the blood, there are no circumstances which lead to the belief, that it contains any particular principle, which it is the chief purpose of the liver to separate.

Secretion and assimilation do not consist in the separation of something already formed; but these functions imply chemical actions.

14. With regard to the manner in which secretion and assimilation take place, very little or nothing is known. The reader has had abundant proof, however, that the first is not the separation of something, already formed in the blood, or the latter, a mere deposition; since, in innumerable cases, compound substances are found in the secretions and in the solid parts, not previously existing in the blood. Hence then chemical decompositions and recompositions must necessarily take place in these vital functions.

15. Notwithstanding these strong facts, there have not been wanting some physiologists, who have denied altogether the agency of chemical attractions in the vital processes. According to them, chemistry, so far from assisting the animal functions, is in perfect war with life; and when the former has gained an ascendancy over the latter, destruction is the consequence. In proof of this assertion, the putrefaction of animal bodies, after death, is alleged.

16. To prove how fallacious this mode of reasoning is, let it be supposed for a moment, that those agencies of matter upon matter, which are called chemical attractions, were annihilated; what would be the consequence? Most unquestionably it would be impossible for any animal to live.

17. But although chemical actions do take place in animal processes, it does not follow that they are beyond the control of other agencies; the fact is that they are not; and life, whatever it may be, whether dependent upon a peculiar

principle or upon organization, is the something which directs them.

Vital agency sometimes yields to the chemical agency.

18. The agency, however, which directs the chemical changes in animals, is not absolute in its power, but yields under extraordinary circumstances. Thus, if peculiar substances be taken into the stomach, they make their way into the secretions, and even into the solids themselves. Musk and indigo have been made to pass into some of the secretions, and the colouring matter of madder into the bone. Hence it would appear, that the digestive organs cannot convert every substance to the purposes of the animal; and that even when unusual substances get into the blood, they cannot always be excluded, by the secreting or assimilating powers, from entering into the composition of the solids and fluids.

Particles composing animals obey chemical attractions.

19. In what manner the control over the ordinary chemical affinities is exercised in the living body, would be difficult to determine. It is not possible, that the particles which compose animal bodies can enjoy any immunity from the influence of the chemical attractions. They cannot constitute an exception to the universal lot of matter. If this position be true, then the springs to chemical action cannot be considered as suspended, but the chemical actions themselves counteracted by opposing actions. Shall it be said, that it is life which is the counteracting force, or are there any agencies which exercise the same influence over chemical affinities out of the body? If there be, then certainly an identity of effect may be fairly ascribed to an identity of cause. Now it has been fully proved, that galvanic electricity has the power of counteracting the ordinary results of chemical affinity; and may not the same agency be the proximate cause of a similar counteraction of chemical affinities in living bodies.

20. After all, even admitting the supposition just stated to be true, still this electrical agency must be under the control of some other power; and this power may be denominated life.

21. As soon as life leaves the body, the different chemical affinities are no longer controlled, and its constituents form compounds totally distinct from its original component parts. A sketch of what is known concerning the changes, which take place under such circumstances, will be given in the following chapter.

CHAPTER V.

OF THE DECOMPOSITION OF ANIMAL BODIES AFTER DEATH.

Dead animal matter putrefies;

1. It is a well known fact, that the matter composing animal bodies, which have ceased to be influenced by vitality, undergoes certain changes, accompanied by the emission of a disgusting fetor. These changes are expressed by the term putrefaction.

if complex in its nature,

2. It does not, however, necessarily happen, that dead animal matter should putrefy. A certain complexity in its composition, by which is meant a mixture of a number of substances already compound, is a necessary pre-requisite to the putrefactive changes. Thus, animal substances, which are uniform compounds, such as oils and resins, do not putrefy. Besides this complexity, dead animal matter requires to be under the influence of heat and moisture, before it can take on the putrefactive process. This is proved by the circumstance, that animal matter, exposed to a freezing temperature, or perfectly dried, undergoes no change whatever. Exposure to air is not an indispensable pre-requisite; for the putrefactive changes take place in close vessels, although somewhat modified under such circumstances.

and subjected to certain degrees of heat and moisture.

Putrefaction described.

3. Animal matter, exposed to the predisposing circumstances just stated, undergoes a suite of changes, of which the following is an outline. If it be a portion of flesh, it first becomes pale and somewhat soft; its texture next begins to be destroyed, and it emits a disagreeable smell. The exposure being still continued, it diminishes in bulk, and exhales an ammoniacal odour. This smell is dissipated by the surrounding air, and is succeeded by the insupportable odour denominated the putrid smell. This continues for some time, but is at last restrained by the production of ammonia. This alkaline base has no sooner been dissipated, than the putrefactive process recommences, and the flesh swells up, emitting a number of air bubbles, and then subsides. At this stage of the decomposition, the fibrous texture of the flesh is scarcely distinguishable, and the whole becomes a soft mass of a brown or greenish appearance, and having a faint and nauseous smell. After this stage of the process, the odour is gradually lost, and the putrefied matter acquires some consistence and a deep colour. It is finally converted into a friable matter, which breaks into coarse powder, like earth, between the fingers. This substance consists of the fixed parts of the animal matter, mixed with some charcoal, oil, and ammonia. The gaseous products vary somewhat, according to the substance which may be subjected to the

putrefactive process; but they consist principally of hydrogen gas, combined with sulphur phosphorus and carbon, of ammonia and carbonic acid gas, and perhaps of azote. Occasionally nitric acid appears to be formed.

It depends upon a new play of affinities.

4. Thus it would appear, that animal matter, after its death, being no longer embarrassed by the operations of vitality, is influenced by a new play of chemical affinities, which causes its ultimate constituents to enter into new and more simple modes of combination.

Putrefaction is retarded and modified in buried bodies.

5. Putrefaction, as already described, must be taken as applying to dead animal matter, putrefying separately and in contact with the air. When buried in the earth, animal bodies putrefy much more slowly; and when a great number of carcases are buried in the same pit, the animal matter is converted into a peculiar saponaceous substance, composed of a fatty matter combined with ammonia. This singular substance was first observed, as the result of the decomposition of animal bodies, under peculiar circumstances, in the burial ground of the Innocents in Paris, where it had been the practice to deposite the bodies of the poor, each in a separate coffin, in large pits, until they were filled nearly to the top, when the whole was covered over by a layer of earth about a foot deep. These pits usually contained from 1000 to 1500 bodies. It has been ascertained, that bodies, so circumstanced, require about thirty years to be converted into this peculiar fatty matter.

Putrefaction of dead animal matter may be prevented.

6. As on many occasions it becomes necessary to preserve, from putrefaction, animal substances to be used as food, so the proper measures, to be pursued with this view, become a very important subject of inquiry. It has already been stated, that the contraries of heat and moisture, namely cold and dryness, suspend the process of putrefaction; and accordingly meat in cold countries is preserved in the winter season by being frozen, and drying is a very common expedient for the same purpose. Besides these means of preventing putrefaction, others seem to act by combining with the substance preserved. In this way, it is probable, that chloride of sodium (common salt) and nitrate of potash (nitre) act in preserving flesh. The manner, in which other substances, such as sugar, acids, alcohol &c. act, is not quite so obvious. Dr. Thomson supposes it is by the affinity of these substances for water, whereby they are enabled to abstract one of the principal agents in putrefaction.

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